THE

AMERICAN NATURALIST.

Vol. IX.—MAY, 1875.—No. 5.

THE LAW OF EMBRYONIC DEVELOPMENT THE SAME IN PLANTS AS IN ANIMALS.

BY I. A. LAPHAM, LL.D.

It is a well known law in the animal kingdon, that the young or embryonic state of the higher orders of animals, resemble the full-grown animals of the lower orders. As examples, we have the tadpole, which is a young frog with gills and a tail, thus resembling the fishes which stand lower in the scale than the reptiles; and the caterpillar which has the characters of a worm, but is the immature state of the butterfly, an animal of a higher class of articulates. The discovery of this important law, and its application to particular cases, has been one of the causes of the recent rapid progress in the study of the animal kingdom; it has enabled naturalists to determine the proper place of certain species in the grand scale of beings, and thus to correct their systems of classification; it has enabled geologists to decide upon the relative age of rocks, in some otherwise doubtful cases.

It is the purpose of this paper, to show, as briefly as possible, that the same law of resemblance between the immature of one order and the mature of a lower order of animals, is equally true in the vegetable kingdom, where its study may hereafter lead to equally important results.

Plants grow from seed planted in the ground, have roots, stem, branches, leaves; they produce flowers with calyx and corolla, and the more essential organs, stamens and pistils; they bear fruit

with seed after their kind, which when planted, swell and become plants again.

The stamens have at their top a sack (the anther) completely filled with grains nicely packed, each of which proves on examination to be a small sack (Fig. 115, the pollen) filled with a viscous fluid matter, in which are floating exceedingly small grains called fovilla. These are essential organs in the reproduction of the plant, and must perform their functions before the seed can be matured. We may increase and multiply plants by layers, cuttings and budding; but to reproduce a new plant, the agency of the stamen, pollen and fovilla, is needed as well as that of the seed.

Fig. 115.

Pollen.

Under a good microscope, this fovilla may be seen in any ripe pollen grains, but the particles are among the most minute things we are called upon to examine; requiring the higher powers of the instrument even to see them; and, what is truly wonderful, these minute particles are found to have a proper motion of their own. They move forward, backward or sidewise, but never make much progress in any direction; the motion appears to be objectless, not like that of an animal seeking its food. The cause of this motion is not known; it is called molecular motion, and may be the effect of some chemical action; but is more probably due to the mysterious vital force.

From the bottom of ponds of stagnant water, and from springy places, we may bring up plants so minute that no unaided human eye has ever seen them; they consist of a single cell; they are the smallest and the very lowest grade of plant-life, the Desmideæ; and yet they are full-grown plants. They never grow to be anything else, they are only Desmideæ and nothing more. They are true plants and not animals, as was once supposed.

These minute, though full-grown plants, will be found actively moving forward and backward and sidewise; making no progress; appearing to have no aim, no object; precisely like the little particles of fovilla from the pollen grains, of the highest orders of plants.

Here then we have the first proof of the existence of the law in the vegetable kingdom; the wonderful motion, both of the full-grown plant of the lowest of the vegetable race, and of the particles, which may be regarded as one of the first steps toward the reproduction of plants of the highest type.

Arctic and Alpine travellers report the snow as sometimes red, and we know that our stagnant waters are sometimes green; these colors are found upon close examination to be owing to other minute one-celled plants called Protococcus (Fig. 116). They are little sacks or cells containing particles of a brilliant carmine-red, or beautiful green color. Each particle within the cell is destined to become a new plant, and then again to give origin to others.

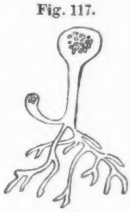
Fig. 116.

Protococcus.

The analogy between these full-grown plants of an exceedingly low grade and the pollen-grains (Fig. 115) of a rose, standing at or near the head of the plant kingdom, is at once apparent. They contain particles (fovilla) destined to the same office of reproduction; one woodcut serves to represent both.

The Botrydium (Fig. 117) may be deemed a plant only a little higher in the scale than the Protococcus. It consists like that of a single cell, but this cell sends down a tube which is often branched, extending off in various directions very much like roots in search of vegetable food. The cell proper is filled as usual with the reproductive particles; and some of the branches become enlarged as shown in the figure, develop other particles and soon separate to form new plants of the same kind.

Fig. 117.



Botrydium.

In this, and in many similar full-grown plants of the lower orders, there is a very striking correspondence with the pollen grains after they have fallen upon the stigma and developed tubes, the pollen-tubes (Fig. 118). In both cases we have a cell with a tube extending downwards from one side, with the vegetable particles and fovilla, and in both, these minute bodies are supposed to pass down the tube to perform their office of originating a new plant.

Fig. 118.

Pollen tube.

Here again the full-grown Botrydium corresponds with the embryonic pollen-tubes of the higher plants; and we have a third proof of the existence of the law.

Fig. 119.

Mould.

Fungi are plants of a higher grade than the Algæ, the Protococcus, and the Botrydium. Instead of a single cell, they consist of an aggregation of cells; and they produce a number of little cases or sacks filled with grains, called spores. Here (Fig. 119)

is the figure of the mould that grows upon bread in a damp cellar. It consists of a single stem made up of cells placed one upon the other, and a single globular spore-case at the top. The spores are liberated when ripe and are blown to the four quarters of the world by the wind. Wherever they alight, circumstances being favorable,—as bread in a damp cellar,—they grow and become mould again. Compare this, which is one of the lowest of the Fungi, with a stamen (Fig. 120) growing in one of the most perfect of flowers. It has its filament (stem) supporting a case or sack (the anther) filled with pollen-grains (which I compare with the spores of the fungi) and which, when fully mature are liberated and scattered about by the wind, or are carried by insects. Under favorable circumstances (falling upon the stigma) they also grow and become new plants.

Fig. 120.

Stamen.

These examples are sufficient for the present purpose; they show clearly the existence of this important law in the vegetable, as well as in the animal kingdom. Many similar analogies might be found throughout the whole course of vegetable life, were it desirable to pursue the subject. We have here one more link between the two great kingdoms of organized nature, and another proof of the unity of design of the Creator.

ON THE PHYSICAL AND GEOLOGICAL CHARACTERISTICS OF THE GREAT DISMAL SWAMP, AND THE EASTERN COUNTIES OF VIRGINIA.

BY PROF. N. B. WEBSTER.

THIS remarkable morass, situated partly in Virginia and partly in North Carolina, is about forty miles long and from fifteen to twenty-five miles wide. The earliest account of a passage through the swamp is by Col. Byrd, who surveyed the state boundary line in 1728. Until this time, Col. Byrd wrote in his journal "this dreadful swamp was ever judged impassable."

About 1755 a Scotchman named Drummond, discovered the pond now bearing his name, and which has since been immortalized by Moore as the "Lake of the Dismal Swamp."

In 1763, George Washington, then twenty-one years of age, penetrated the swamp and in his own language "encompassed the whole." He camped one night on the eastern border of the lake, which is about seven miles long and five in width, and in a morning ramble before breakfast, made the interesting discovery that the water of several very small streams ran *out* of, instead of *into*, the lake. Washington wrote to Hugh Williamson that he had no doubt the water was running into some of the rivers of Albemarle Sound. The youthful surveyor had in fact discovered the source of Northwest River which runs into Currituck Sound.

Washington also ascertained that the surface of the lake was nearly level with the western edge of the swamp and considerably higher than the eastern border, or in other words that the swamp was neither a *hollow*, nor a *plain*, but a *hill-side.* More careful measurements since have shown that the surface of the lake is twenty-one feet higher than mid-tide, and twelve feet higher than the eastern border of the swamp.

Com. Barron and others sounded across the lake and found the depth, in the middle, to be fifteen feet, with a bottom of swamp-mud, covered in some places with white sand. The soil, if soil it can be called, taken one foot below the surface, contains more than 96 per cent. of organic matter. Workmen in the swamp assert that they can run a pole down from ten to fifteen feet in this soft mud or sponge. This sponge is really a peat when taken near the surface, and has been used as fuel. Shaded and kept moist by the dense growth of ferns, reeds, and juniper trees, which with their long deep roots stand firm in the trembling mud, the annual accumulation of vegetable growth does not decay, but gradually aids in raising the level of this growing bog. But when the mud is thrown up in ridges by the excavations for ditches and canals, it soon disappears by a slow oxidation.

The trees of past centuries, buried in the swamp, as well as the present growth are of great value for shingles, staves, and other purposes where durability is desired.

During dry seasons extensive fires prevail, not only burning the vegetation above the surface but the peaty soil itself, leaving holes and large depressions sometimes two feet in depth.

In this way the lake was probably formed. It is not to be supposed that the bed of the lake was thus burned to the depth of fifteen feet, but that at some remote time, the large area of its

bed was burned so low, that the water from succeeding rains filled it to a depth too great to allow vegetable growth, and that each succeeding year added to the height of the banks or relative depth of the lake. The perpendicular banks of the lake and the charred stumps that have been formed at the bottom, confirm this supposition. There are many proofs that the water supply of the lake is from the rainfall on the swamp and not from springs at the bottom. The water is remarkably pure except from vegetable matter infused, which gives it the color of weak tea and the name of juniper water. It is considered the best water for long sea voyages. Contrary to popular opinion abroad, the interior of the swamp is a very healthful locality.

Lyell briefly refers to the swamp in his "Travels in North America," and of course sees a confirmation of his theory of coal formations, viz.—"That ancient seams of coal were produced, for the most part, by terrestrial plants of all sizes, not *drifted*, but *growing on the spot.*"

That the Great Dismal was once much greater is evident from the deposits of peaty matter, swamp mud, and burnt stumps, below from twelve to fifteen feet of clay, at the distance of several miles from its present limits.

A specimen of charred wood was taken from a well about five miles from the swamp, and perhaps a mile from Suffolk, Va., on the line of the seaboard railroad. It was found as a part of a large stump, where it had grown in the midst of the black peaty soil, and below six and one-half feet of swamp mud, two feet of blue clay, and twelve feet of red clay. In the mud about the roots of the stump, white sand was found as at the bottom of the lake.

It is well known that the southeastern part of Virginia consists of two plateaus, one about eight or ten feet above the sea and the other from twenty-five to forty feet. The well referred to was dug near the eastern edge of the higher plateau, and the surface of the swamp forms an inclined plane from one plateau to the other.

This vast swamp appears to be retained above the level of the adjacent land in a way similar to the peat-mosses of Solway and Sligo, until they burst and overwhelmed the neighboring country. What known force but that combination of molecular forces known as capillarity can supply and sustain the waters of the lake and swamp above described?

THE FERTILIZATION OF CERTAIN FLOWERS THROUGH INSECT AGENCY.

BY THOMAS G. GENTRY.

IN the spring of 1873, a few seeds of *Cucurbita ovifera* were sown in a box which had been previously filled with rich earth from the woods. In course of time they germinated, producing thrifty plants. After the latter had attained suitable heights for removal, some were transferred to the garden, and the remainder were given to friends in the vicinity; a few of the latter found their way to a thickly-built up portion of Philadelphia, and trained to grace the walls of an outhouse. All the plants flourished and fruited abundantly. The city fruit was the exact similitude of the original, globular in configuration, with a small curved neck, and of a light yellow color with a circular patch of green upon the basal part. The country plants produced more than a dozen gourds to the vine, which differed very materially from the original in size, form, and color. With one exception they were globular in shape, attaining in some instances a circumference of nearly three feet, and of a deep rich gamboge color. The exceptional case was perceptibly flattened at the ends, and marked with alternate longitudinal broad bands of deep and light shades of green, affording a striking contrast in color to the others. There was particularly noticeable in the fruit, a very close resemblance in outline and color to the ordinary pumpkin, *C. pepo*, and, indeed, the flavor and thickness of the flesh were so pumpkin-like, as to convince one unfamiliar with the facts, that it was truly the case. Whence the difference between the city fruit and that matured in the country? I think it must be attributed to the agency of insects. Many of the Bombi, for instance, *Bombus pensylvanica*, together with the little honey bee, *Apis mellifica*, were observed on scores of occasions by the writer, to visit the female flowers of *C. ovifera*, doubtless, through mistake, fancying them to be the pollen-bearing ones, with their posterior *trophi* laden with yellow pollen-grains gathered from *C. pepo*. In alighting upon a flower, a Bombus could not avoid brushing its posterior limbs against the bilobed stigmas thereof.

Here, it is evident, is a case of hybridism brought about through

the agency of bees, whereby a cross between two closely-allied species has been effected in an eminently successful manner, if the size, quality, and profusion of the fruit are any criteria. In the city specimens, fertilization has undoubtedly been accomplished through wind-agency. It is extremely doubtful that bees could have taken any part therein, since it is a rare occurrence to meet with them in a compactly built city; their presence being rarely ever observed except where conveniences for nest-building and abundance of food are met with.

Bees were also noticed by the writer to visit the female flowers of *C. ovifera*, after having previously collected pollen from the male flowers of the same vine. From this and the preceding fact, it would seem that the pollen of a very near ally has sometimes a prepotent influence over the plant's own pollen.

In Gray's Manual it is affirmed that *C. ovifera* is probably the parent of *C. pepo*. That there is a close relationship subsisting between them amounts to a settled conviction in my mind. The perfect freedom with which *C. ovifera* receives the pollen of *C. pepo*, in preference to its own, is what I should expect, if the latter has been evolved from the former, which I presume to be the case.

Supported by a trellis in front of my door, there is growing a beautiful and thrifty vine of *Wistaria Sinensis*. When the season is favorable, it is an early bloomer, throwing out its lovely purple, pendent racemes, days in advance of its long, graceful compound leaves. Its flowers usually appear with the various species of Bombi, Xylocopa and Apis, and are sources of attraction to them when other and richer sweets are absent. During the last spring my attention was attracted to these flowers, by the incessant hum which always saluted my ears when returned from my day's labors.

From morning until night, as long as the flowers remained, these busy creatures were engaged. There were *B. pensylvanica*, *B. virginicus* Fab. (queens); *Xylocopa virginica* (female) and *Apis mellifica* (worker). After watching them on many occasions for more than an hour at a time, I was surprised to discover how few entered the flowers in front for the honey which they secrete. They almost invariably perforated the vexillum. Having witnessed this operation many times, I set to work finally, to examine each individual flower of many clusters. The result of my labor showed that nearly every flower had been thus perforated. Judging from the sizes of the apertures, they were evidently the work of the

Bombi and Xylocopa; the proboscis of the honey-bee being too small and narrow to produce such results. Although hundreds of honey-bees were flying from flower to flower, not a solitary individual was noticed to enter the throats of the same. Like their larger and distant relatives, they took the shorter road. As a general rule, the little Apis enters in front. In this instance I can only attribute its deviation from custom to the power of imitation. Perceiving that the coveted material was to be had, at a great saving of labor and time, as evidenced by the examples of Bombus and Xylocopa, it had learned to profit thereby.

Although the purpose for which nature had created the flowers of Wistaria seemed to be defeated, viz., the propagation of its kind and the continuance of the species, as made manifest through previous observations, yet I did not cease to give them attention when opportunities offered. After long and weary watching for nearly one whole afternoon, I was repaid for my patience and watchfulness, by witnessing an individual of *Bombus pensylvanica* enter a flower. After this I had the gratification of witnessing similar operations performed by several others.

In order that the process may be understood, it is necessary to give a detailed description of the structure of a normal flower. In *papilionaceous* flowers, the corolla is perigynous; of five irregular petals (rarely fewer). The upper or odd petal, called the *vexillum*, is larger than the others, enclosing them in the bud, and when open is usually turned backward or spreading. The two lateral ones are called the *wings* and are situated obliquely and externally to the two lower petals; the last are connivent and more or less coherent by their anterior margins, forming a body named the *carina* or keel which usually encloses the stamens and pistil. The stamens are ten in number, diadelphous; nine in one set, in a tube which is cleft on the upper side, that is, the side next to the *standard*, and the tenth or upper one separate.

From the position of the stamens and pistils in a normal flower, the former being curved forward and overhanging the latter, it would seem that the object to be attained is the fertilization of the flower by its own pollen. But a knowledge of the degree of perfection to which the sexual parts have attained, after the release of the wings and carina from the enveloping vexillum, dissipates any such opinion. The anthers have not acquired their full development, while the stigma is perfect, judging from the viscid secre-

tion which covers its surface. By the time the anthers mature, the stigma has begun to wither. As the lower flowers of a cluster come to perfection before the upper ones, or rather as flowers may be found on the same raceme in various stages of development, it is possible to meet with some that mature their pistils at the same time that others do their stamens. It is obvious from the above that self-fertilization is out of the question. In confirmation thereof, I might cite the important fact that on a vine that produced no less than one hundred clusters, each bearing at least fifty flowers, but eight legumes were counted; seldom more than one was found on the same flower stalk; in one case I observed two.

When a Bombus visits a flower, it alights upon the *vexillum*, and in order to get to the honey, thrusts its proboscis downward between the *keel* and *standard* which are in close contact. The effort thus expended forces the carina backward which releases the second set of stamens and the pistil (the first being already free) from their confinement. The pollen-grains being already ripe, become dislodged from their box-shaped anthers, and fall down upon the head and back of the bee. The bee passes to another flower, further up on the same stem. The same process is effected, which permanently releases the stamens and pistils (the former being undeveloped). In the act of retiring, the head and sometimes the back come into contact with the stigmatic surface of the pistil which projects slightly beyond the stamens, and which being abruptly curved downward, cannot escape fertilization.

At the time of writing, June 29, 1874, a second crop of flowers is visible. These are principally secondary clusters, which have pushed from the long, pendent compound leaves, which are to be observed at the basal third of the primary floral axes. For more than a week I have attentively watched these flowers, in the hope of witnessing the visits of bees. Up to the present moment it has not been my privilege. Bombi pass and repass without being attracted. Within the woodwork of the trellis which supports the vine, are several burrows of *Xylocopa virginica*, and within a few inches of the aperture which forms the mode of ingress and egress, there is hanging a cluster of flowers, whose conspicuous color of purple and strong fragrance could not fail to invite attention and induce acceptance, were there a disposition upon the part of this insect.

When the clovers, particularly *Trifolium prætense*, are in blos-

som, and the delicious sweets which they yield are eagerly sought after, all other luxuries are held at a discount. Bees appear to be very fastidious, so to speak, in their tastes; seldom noticing plants of inferior qualities, except as necessity demands.

July 14th. The flowers have all fallen and not a legume, nor the trace of one, from this second flowering is to be seen. During repeated examinations of these secondary clusters, there was observed nothing in the structure of the stamens and pistil of any flower, to prevent self-fertilization, provided they had come to maturity at the same time. There was abundance of pollen in the anthers, and the stigmatic surface of the pistils was open and coated with a viscid secretion. The presence of bees and the development of fruit in a few instances where aided by those insects, associated with the opposite condition, to wit, the absence of bees and the consequent absence of fruit, the flowers being ready but the bees being unwilling, are incontrovertible evidence of the fact that bees are essential to the fertilization of *Wistaria Sinensis*.

BOTANICAL OBSERVATIONS IN SOUTHERN UTAH.

BY DR. C. C. PARRY.

No. 4.

THE following list comprises the collection of plants made in the above district, in the season of 1874.

The numbers given correspond to those affixed to the distributed sets, and referred to in the previous papers. Where no numbers are given the plants named were either scantily collected, or merely observed. In a few instances the unnumbered plants, though belonging to this locality, were derived from other sources as indicated in the text. Where no special locality is given, the valley of the Virgen in the vicinity of St. George is to be inferred. To the notes and descriptions following any particular species furnished by other collaborators, the name of the author is appended.

No. 1. *Anemone decapetala* L. Rocky ledges. April.

No. 2. *Ranunculus Andersonii* Gray, Var., *tenellus* Watson. King's Rep. p. 7, t. 1.

Forming small clumps, with the flowering stems quite constantly branched; Beaver-dam Mts. May.

No. 3. *Delphinium azureum* Michx.

No. 4. *Myosurus aristatus* Benth. Santa Clara. May.

No. 5. *Berberis Fremontii* Torr. Beaver-dam Mts. May.

No. 6. *Arctomecon Californicum* Torr. Fremont's Rep. p. 312, t. 2. Dry gypseous hills on the Virgen. May. Differs from the description and figure above referred to, in its less hairy foliage, 4 (not 6) valved capsule, and white flowers; apparently biennial.

No. 7. *Eschscholtzia Californica* Cham., var. *hypecoides* Gray.

No. 8. *Platystemon Californicus* Benth. Upper Santa Clara. June. The most eastern locality from which this well known Californian plant has been collected.

No. 9. *Arabis longirostris* Watson. King's Rep. p. 17, t. 2.

No. 10. *Streptanthus cordatus* Nutt. Beaver-dam Mts. May.

No. 11. *Draba cuneifolia* Nutt. Rocky ledges. April.

No. 12. *Capsella divaricata* Walp.

No. 13. *Thysanocarpus curvipes* Hook.

No. 14. *Physaria Newberryi* Gray. Bot. Ives', Rep. p. 6. This species seems to take the place of the more common northern species, *P. didymocarpa* Hook., in all the mountainous districts of Southern Utah.

No. 15. *Biscutella (Dithyræa) Wislizeni* Engel. Sand drifts.

No. 16. *Lepidium integrifolium* Nutt., var. *heterophyllum*. Leaves more or less serrate or pinnatifidly lobed.—The present specimens have the leaves coarsely toothed, in the lowermost somewhat lobed, the upper being entire. No. 122 Watson (*L. montanum*, Var. (?) *alpinum*, King's Rep. p. 29), is a more extreme form with most of the leaves lobed. In every other respect the plant is exactly Nuttall's *L. integrifolium* (51 Vasey; 620 Wolf) which has leaves only few-toothed at the apex or entire. The species is provided with a somewhat woody base and thick leaves, glabrous, the petals conspicuous, capsule ovate to orbicular, marginless or very nearly so. Rocky ridges near Cedar City. July.—S. WATSON.

No. 17. *Lepidium Fremontii* Watson. King's Rep. p. 30, t. 4. Profusely branched from a perennial woody base, forming diffuse globular shaped clumps, 1-2 feet in height, with copious racemes of small white flowers, succeeded by crowded clusters of slender pedicellate, broadly obcordate siliques. The figure above referred to in Watson's Report, taken from an imperfect fragment, does not do justice to this fine well marked species. Abundant on rocky hill sides near St. George, flowering in May.

No. 18. *Lepidium montanum* Nutt.

No. 19. *Lepidium Wrightii* Gray. Siliques more glabrous than in the typical specimens.

No. 20. *Arenaria Fendleri* Gray, Var. *glabrescens* Watson. A much finer plant than the more common northern form and admirably adapted for ornamental rock work.

No. 21. *Stellaria Kingii* Watson King's Rep. p. 39, t. 6, fig. 1-2. Interior basin of Central Utah. July.

No. 22. *Lewisia brachycalyx* Engelm.

No. 23 and 24. *Claytonia perfoliata* Don., Vars. Shaded crevices of Sandstone rocks. Santa Clara. April.

No. 25. *Sphæralcea Emoryi* Torr.

No. 26. *Malvastrum exile* Gray. Bot. Ives's Rep. p. 8.

No. 27. *Glossopetalon spinescens* Gray. Pl. Wright. Pt. 2, p. 29, t. 12. Beaver-dam Mts. May.

No. 28. *Larrea Mexicana* Moric.

No. 29. *Acer grandidentatum* Nutt.

No. 30. *Vitis Arizonica* n. sp. Young branchlets, leaves and inflorescence densely floccose-tomentose, adult naked or usually (at least on the nerves of the leaves) beset with short hairs; leaves (small) orbiculate, cordate, with a wide (sometimes very broad) sinus, acute, with irregular, sharp, often very pointed, rather small teeth; rarely 3-5- lobed with rounded sinuses; tendrils intermitting,[1] branched; fertile inflorescence

[1] *Intermitting* tendrils we find in those species of *Vitis* where two leaves with opposed tendrils are succeeded by a third leaf without a tendril, and so on in succession:

and bunches of berries shorter than leaf; berries small or middle-sized (2-3½ lines in diameter); seeds mostly 2-3, usually obtuse with a small but prominent chalaza and more or less indistinct raphe. *Vitis æstivalis*, Var? Gray, Pl. Wright, pt. 2, p. 27. Torrey Pac. R. Rep. 7, Bot. p. 9.—Common along the streams of Arizona where it was first collected by the botanists of the Mexican Boundary, and of some of the Pacific Railroad Expeditions; later by Dr. Palmer, who made an especial study of it and gathered numerous specimens in mature fruit; Dr. Parry's collections are from southwestern Utah.

With some hesitation I venture to introduce a new species in this intricate genus, and especially in the Cordifolia group; but as this form cannot well be united with any of its allies, it will have to try and stand for itself. The forms belonging to the Cordifolia group are distinguished by their more or less entire leaves and small berries; they extend over the whole breadth of the continent from northeast to southwest, and are *V. cordifolia* with larger, broadly dentate, glabrous leaves and smallest berries in larger bunches, raphe usually strongly developed on the top of the seed as a well marked cord; from New England to Missouri, Nebraska and Texas; *V. riparia* with larger, incisely dentate, usually sharply 3-lobed, glabrous leaves, larger berries in small bunches, raphe slightly visible on top of seed; from Canada to the Rocky mountains and to Texas; *V. Arizonica* with smaller, broadly cordate, sharply dentate leaves, floccose at first, glabrous afterwards, middle-sized berries in small bunches, raphe more or less indistinct on top of seed; *V. Californica* with middle-sized, narrowly cordate, broadly dentate, always tomentose or canescent leaves, small berries in large bunches, raphe invisible on the broad seed; found only on the Pacific slope, from the Sacramento valley southward.

The fruit of *V. Arizonica* belongs like that of *V. riparia* to the better class of American grapes; while that of the two others is scarcely edible, this is said to be quite luscious, and will in time no doubt be cultivated, in a warmer climate. Dr. Palmer's seeds have well germinated with me, but the vines perished in the climate of St. Louis, after a lingering existence of several years. The seeds show a remarkable variability in form and markings so as to weaken to some extent their specific value. I find them generally obtuse, but emarginate and even notched on top; the chalaza is small but usually quite prominent and is narrowed upwards into the raphe, which on the top of the seed becomes inconspicuous, or in some instances remains quite prominent.

Dr. Parry's specimens from southwestern Utah are distinguished from all the Arizona specimens I have seen, by having somewhat lobed leaves. Their sterile flowers exhibit the usual form; longer anthers on long straight filaments, which in the bud are inflexed; in the fertile flower-bud the stamens are shorter than the pistil, the filaments straight and scarcely as long as the short anthers, and after fecundation recurved. I could discover no difference in the condition of the pollen of both kinds of flowers. This seems to be the ordinary form of the fertile flowers in our wild species, and in some cultivated ones, while some other stocks bear fertile flowers with long stamens, thus constituting the incompletely polygamous character of our grape-vines; purely pistillate flowers I have never seen, and doubt whether they exist.—DR. G. ENGELMANN.

No. 31. *Krameria parvifolia* Benth.

No. 32. *Polygala subspinosa* Watson. Am. Nat. Vol. vii, p. 299. Cedar City. July.

No. 33. *Vicia exigua* Nutt.

No. 34. *Trifolium Kingii* Watson. King's Rep. p. 59. Intermediate in some respects between *L. Bolanderi* Gray, and *S. Beckwithii* Brewer.

No. 35. *Trifolium eriocephalum* Gray. Sheep range, Cedar City. July.

No. 36 and 38. *Hosackia rigida* Benth, Vars.

No. 37. *Hosackia rigida* Benth.

No. 39. *Hosackia subpinnata* Torr. & Gray.

---

the ordinary occurrence in all our grape-vines with the exception of *V. Labrusca* and its cultivated varieties; in these the tendrils are *continuous*; *i. e.*, each leaf has a tendril opposed to it; all this only in well-grown canes. This character distinguishes at once all forms of *Vitis Labrusca*. *Branched* tendrils are found in all our species, with the exception of *V. vulpina*, which bears *simple* tendrils.

No. 40. *Dalea Johnsoni* Watson. King's Rep. p. 64.

No. 41. *Lupinus pusillus* Pursh. An unusually robust and showy form, frequently branching; 4–8 inches high.

No. 42. *Lupinus brevicaulis* Watson. King's Rep. p. 53, t. 7.

No. 43. *Lupinus* (*Platycarpos*) *Sileri* Watson. Proc. Am. Acad. vol. x, p. 345. N. sp. Low, caulescent, branching, loosely and softly villous; leaflets 5, oblanceolate 5–8 lines long, acutish, smooth above, shorter than the slender petioles; racemes short, few flowered, on elongated peduncles equalling the leaves; pedicels short, scattered; bracts shorter than the calyx; bractlets linear; calyx-lobes herbaceous, toothed, 3 lines long, the upper a little shorter; petals light-purple, 3–4 lines long; pod 4–5 lines long; seed a line or more broad.

An interesting addition to this section of the genus, distinguished readily from *L. pusillus*, by its more slender habit, softer pubescence, and capitate long-peduncled racemes. Washington Co., S. Utah (A. L. Siler, 1873); Loma on the Rio Grande, S. Colorado (195 Wolf). S. WATSON. Pine valley, S. Utah (Parry 1874).

No. 44. *Astragalus eriocarpus* Watson. King's Rep. p. 71.

No. 45. *Astragalus arrectus* Gray. Beaver-dam Mts. May.

No. 46–49. *Astragalus cyaneus* Gray. Pl. Fendl. p. 34. This species seems to be well distinguished from *A. Shortianus*, to which it has been referred, by the legumes which are broadest near the middle and more or less attenuate into the calyx especially when immature, and by the narrower oblong acutish leaflets. In *A. Shortianus* the wider pod is rounded at base and strictly sessile, the leaves suborbicular, mostly obtuse or retuse, and the pubescence of the calyx not closely appressed as in the other. *A. Shortianus* has been collected in the mountains of Colorado; *A. cyaneus* in New Mexico and Arizona. S. WATSON.

No. 47. *Astragalus atratus* Watson. King's Rep. p. 69, t. 11.

No. 48. *Astragalus diphysus* Gray. Cedar City. July.

No. 50. *Astragalus Nuttallianus* DC. Var. *canescens*.

No. 51. *Astragalus megacarpus* Gray, Var. Cedar City. July.

No. 52. *Astragalus lonchocarpus* Gray. Cedar City. July.

No. 53. *Astragalus Sonoræ* Gray. Cedar City. July.

No. 54. *Astragalus Kentrophyta* Gray. Cedar City. July.

No. 55. *Oxytropis campestris* L. High mountains near Cedar City. July.

No. 56. *Prunus* (*Emplectocladus*) *fasciculata* Gray, Proc. Am. Acad. Vol. x, p. 70. *Emplectocladus fasciculatus*, Torr. Pl. Frem. in Smith's contr. p. 10, t. 5. Abundant on all rocky slopes in the valley of the Virgen; fl. April; fr. June, popularly known in this section as "the wild almond."

No. 57. *Coleogyne ramosissima* Torr. Pl. Frem. in Smith's Contr. p. 8, t. 4. Flowering in May, fruiting in June. A very common shrub on the hills near St. George; foliage deep green; flowers bright yellow, copious. The mature fruit is said to be greedily browsed on by sheep who thrive on it.

No. 58. *Cercocarpus ledifolius* Nutt.

No. 59. *Cercocarpus intricatus*, n. sp. Watson, Proc. Amer. Acad. vol. x, p. 346. (*C. breviflorus* of King's Rep., p. 83, not of Gray). Cedar City. July.

No. 60. *Cowania Mexicana* Don.

No. 61. *Heuchera rubescens* Torr. Stansb. Rep., p. 388, t. 5.

No. 62. *Ribes viscosissimum* Pursh. Pine Valley. June.

No. 63. *Œnothera albicaulis* Nutt., var. (?) *decumbens*. Low, sending out from the base decumbent naked branches; leaves oblong-lanceolate, petioled, sinuate, dentate; common in dry, sandy soil near St. George. — WATSON.

No. 64. *Œnothera Johnsoni* n. sp. Resembling *Œ. primiveris*, but the flowers large and yellow, and the stigmas elongated. Petals one inch long, the calyx-tube equalling or exceeding the leaves; capsules 9–12 lines long, somewhat 4-angled, strongly nerved, not crested. Common on all dry hills near St. George. Dedicated to I. E. Johnson, Esq.

No. 72. *Œnothera* (*Chylismia*) *Parryi*, n. sp. Low, diffusely branched from the base, villous with spreading hairs; stems leafy; leaves ovate to oblong-lanceolate, ½–1 inch long, sub-sinuately toothed, cuneate or sometimes cordate at base, upon a slender, often

elongated petiole; the slender branches and petioles subtended by small sessile bracts; flowers deep yellow or orange, occasionally spotted with red inside, 3–4 lines broad; calyx-tube ½ line long, narrow, the tips of the lobes not free; capsule smooth, 4–6 lines long, ascending upon the more or less deflexed slender and often elongated pedicel.—Distinguished from any form of *Œ. scapoidea*, by its smaller capsules, more deflexed pedicels, bright yellow flowers and peculiar habit. Abundant in bare gypseous clay hills near St. George; fl. May.—S. Watson.

No. 73. *Œnothera brevipes* Gray. Very variable in size, from 4 to 18 inches high. Rocky hill-sides near St. George; fl. May.

No. 74. *Œnothera brevipes* Gray, var. *parviflora*. Of a much more branching habit than the preceding; the leaves more distinctly pinnate; inflorescence more slender; flowers pale yellow, the petals 2–3 lines long.—S. Watson.

No. 75. *Petalonyx Parryi*, n. sp. Gray, Proc. Amer. Acad., vol. x, p. 72. Frutescent, branches leafy up to the condensed spicate heads of flowers; lower leaves oblong or spatulate, entire, sub-sessile, upper ones larger, rhomboid obovate or ovate, crenate, acute at base, short petiolate; lobes of the calyx linear, twice as long as the ovary, a little shorter than the yellow unguiculate petals. Closely resembling *P. nitidus* Watson, of southern Nevada. A low branching suffrutescent plant with copious remains of dead stalks and faded leaves of a pearly white color. Found at only a single locality near St. George; fl. June.

No. 76. *Mentzelia multiflora* Nutt. The common form.

No. 77. *Mentzelia multiflora* Nutt. Var.

No. 78. *Mentzelia multiflora* Nutt. Var. (?). See above page 19.

No. 79. *Mentzelia (Eucnide) urens* Parry. Gray, Proc. Amer. Acad., vol. x, p. 71. Sub-erect, branching, very hispid with stinging bristles intermixed with smaller, many-barbed hairs; leaves orbicular, unequally sub-dentate, penninerved, lower petiolate, upper sessile, partly clasping at the base; peduncles and pedicels short, sub-corymbose; flowers large, petals light yellow, obovate, mucronate, often tipped with a small tuft of hairs, nearly twice as long as the lanceolate lobes of the persistent calyx, deciduous at maturity in a single piece with the very numerous stamens and united filaments forming an internal corona. Sub-pendent from crevices of perpendicular sandstone rocks on the Santa Clara; fl. June.

Mentzelia (Bartonia) tricuspis n. sp. A span high, rather stout, sparsely hispid with slender, simple bristles, and roughish with the shorter and peculiar pubescence of the group; leaves petioled, oblong-lanceolate, acute or acuminate, sinuately pinnatifid-toothed; flowers very short-peduncled, large; calyx bracteolate, its lanceolate subulate lobes about the length of the turbinate tube, and half the length of the 5 spatulate-obovate, light yellow petals; stamens very numerous, all nearly alike and antheriferous, rather shorter than the calyx; filaments narrowly linear, slightly dilated upwards, white with an orange colored base near the tricuspidate apex, the subulate lateral cusps sterile, and twice the length of the middle one, which bears the oblong-linear anther; style 2-cleft; ovules pretty numerous, apparently in two series on each placenta. Apparently annual, only a single specimen brought by the mail-rider from the desert districts south of St. George. May.—A. Gray.

No. 80. *Cymopterus purpureus* Watson. Am. Nat., vol. vii, p. 300.

No. 81. *Myrrhis occidentalis* Benth. & Hook. High mountains near Cedar City. July.

No. 82. *Ligusticum scopulorum* Gray. Proc. Am. Acad., vol. vii, p. 347. Elevated sheep ranges of the Wahsatch near Cedar City; July. The remarkable persistence of this species in the locality indicated, where it is found covering extensive tracts to the exclusion of other more nutritious vegetation—one of the few native plants that can maintain and even extend its foothold under the usually destructive agency of sheep grazing—is very suggestive in its bearing on the question of the modifying influence of cultivation and settlement on the native vegetation of any newly occupied district. A somewhat similar condition of things in southern Colorado has lately given rise to actual warfare between sheep and cattle herders, the latter contending that the introduction of sheep and close grazing favors the growth of plants poisonous to cattle.

No. 83. *Peucedanum Newberryi* Watson. Am. Nat., vol. vii, p. 301.

No. 84. *Cymopterus terebinthinus* Torr. & Gray.

No. 85. *Peucedanum macrocarpum* Nutt.

No. 86. *Galium acutissimum* Gray. Dry rocky slopes on the Santa Clara.

——. *Galium multiflorum* Kellogg. Mountains near Cedar City.

No. 87. *Symphoricarpus longiflorus* Gray. Revis. Symph. Jour. Linn. Soc., vol. xiv, p. 12. A slender, intricately branching shrub with small leaves and long slender corolla, white, tinged with pink; 2-3 feet high; abundant among shaded rocks adjoining the Virgen; fl. June.

No. 88. *Symphoricarpus oreophilus* Gray. Revis. Symph. Jour. Linn. Soc., vol. xiv. p. 12. Mountains near Cedar City. July.

No. 89. *Brickellia linifolia* D. C. Eaton. King's Rep., p. 137, t. 15. Cedar City. July,

No. 90. *Brickellia atractyloides* Gray. Proc. Am. Acad., vol. viii, p. 200.

No. 91. *Aster tortifolius* Gray. Proc. Am. Acad., vol. vii, p. 353. A common, large-flowered, pale blue species, growing in rock-crevices near St. George; fl. May.

No. 92. *Erigeron Bellidiastrum* Nutt.

No. 93. *Erigeron stenophyllum*, var. *tetrapleurum* Gray. Very showy with its light blue, copious rayed flowers, growing in crevices of sandstone rocks near St. George; fl. June.

No. 94. *Townsendia strigosa* Nutt. Cedar City. July.

No. 95. *Solidago pumila* Nutt. Cedar City. July.

No. 96. *Acamptopappus sphærocephalus* Gray. Proc. Am. Acad., vol. viii, p. 634; Torr. in Pacif. R. R. Expl., vol. vii, p. 12, t. 6. Common on dry hills near St. George; fl. June.

No. 97. *Aplopappus linearifolius* DC. Sandstone rocks on the Santa Clara. May.

No. 98. *Franseria dumosa* Gray. Abundant near St. George. When in full bloom, in May, the abundant pollen discharged acts as an irritant sternutatory.

——. *Franseria eriocentra* Gray. Proc. Amer. Acad., vol. vii, p. 355. A shrub 3-4 feet high; only late fruiting specimens collected. June.

No. 99. *Hymenoclea Salsola* Torr. & Gray. Pl. Fremont, in Smith's Contrib., vol. vi, p. 14, t. 8.

No. 100. *Monoptilon bellidiforme* Torr. & Gray. Journ. Bost. Soc. Nat. Hist., vol. v, p. 106, t. 13. Only before known from a single Fremontian specimen. St. George; fl. May.

No. 101. *Chænactis macrantha* D. C. Eaton. King's Rep., p. 171, t. 18.

No. 102. *Chænactis stevioides* H. & A. St. George. May.

No. 103. *Chænactis carphoclinia* Gray. Bot. Mex. Bound., p. 94.

No. 104. *Actinolepis lanosa* Gray. Proc. Am. Acad., vol. ix, p. 198, note.

No. 105. *Actinolepis Wallacei* Gray. Proc. Am. Acad., vol. ix. p. 198, note.

No. 106. *Syntrichopappus Fremontii* Torr. Pacif. R. R. Rep., vol. iv, p. 106, t. 15.

No. 107. *Hymenopappus luteus* Nutt. Pine Valley. June.

No. 108. *Thelesperma subsimplicifolium*, var. *scaposum* Gray. Bot. Mex. Bound., p. Pine Valley. June.

No. 109. *Thelesperma subnudum* n. sp., Gray. Proc. Am. Acad., vol. x, p. 72. Low, short-leafy from a much divided perennial base; leaves thickened, rigid, 1-2-ternate, segments short, linear-lanceolate or oblanceolate; peduncles simple, scapiform, about a span high, rays none: achenia smooth, surmounted by an obtuse 4-5 toothed naked corona. Cedar City. July.

No. 110. *Gymnolomia Nuttalli* Gray. Pine Valley. June.

No. 111. *Actinella Richardsonii* Nutt. Var. (?). Pine Valley. June.

No. 112. *Layia glandulosa* H. & A. Bot. Beech., p. 358.

No. 113. *Tessaria borealis* T. & Gr. Pl. Fendl., p. 75; Sitgr. Rep., t. 5.

No. 114. *Psathyrotes annua* Gray. Pl. Wright, part 2. p. 100.

No. 115. *Psathyrotes ramosissima* Gray. Proc. Am. Acad., vol. vii, p. 363, note. Upper and lower surface of the leaves scurfy pubescent; the edges of the leaves and petioles closely set with ciliate jointed hairs, looking under a lens like a string of beads. These swollen glandular portions contain the aromatic resinous oil that gives the peculiar heavy odor to all the species of this genus, being most marked in this particular one.

——. *Psathyrotes Schottii* Gray. Proc. Am. Acad., vol. ix, p. 206. A single speci-

men of this well-marked species was brought by the mail-rider from the lower valley of the Virgen.

No. 116. *Baileya pleniradiata* Harv. & Gray. Pl. Fendl., p. 105.

No. 117. *Stylocline micropoides* Gray. Pl. Wright., part 2, p. 84.

No. 118. *Tetradymia spinosa* H. & A.

No. 119. *Tetradymia glabrata* Torr. & Gray. Pacif. R. Rep., vol. ii, p. 122, t. 5. Sevier Valley.

No. 120. *Gaillardia acaulis* n. sp. Gray, Proc. Am. Acad., vol. x, p. 73. Low, perennial, puberulent; leaves much crowded on the thickened caudex, slightly fleshy, obovate, petiolate with undulate or sub-dentate margins; scape naked, less than a span high, monocephalous; involucre shorter than the disk, outer scales ovate-oblong, inner lanceolate, slenderly acuminate; flowers of the ray and disk yellow; chaff of the receptacle short, ovate-subulate; lobes of the disk-flowers triangular-ovate, somewhat obtuse; scales of the pappus 9, ovate-oblong, pointed.—Gypseous clay hills near Cedar City. July.

Nos. 121, 122. *Gaillardia pinnatifida* Torr.

No. 123. *Senecio Douglasii* DC., var. (?).

No. 124. *Artemisia trifida* Nutt. Valley of the Sevier. July.

No. 125. *Dicoria canescens* Torr. & Gray. Bot. Mex. Bound., p. 85, t. 30. Only a few immature plants obtained, showing it to be an annual, apparently flowering in August or September.

No. 126. *Cnicus undulatus*, var. *canescens* Gray. Proc. Am. Acad., vol. x, p. 42.

No. 127. *Cnicus Arizonicus* Gray. Proc. Am. Acad., vol. x, p. 41. Cedar City. July.

No. 128. *Lygodesmia grandiflora* Torr. & Gray. Gray, Proc. Am. Acad., vol. ix, p. 217, note. Cedar City. July.

No. 129. *Glyptopleura setulosa* Gray. Proc. Am. Acad., vol. ix, p. 211. Biennial; fl. May. See above, AM. NAT., vol. ix, p. 20.

No. 130. *Malacothrix Coulteri* Gray. Proc. Am. Acad., vol. ix, p. 213, note.

No. 131. *Malacothrix sonchoides* Torr. & Gray. Gray, Proc. Am. Acad., vol. ix, p. 214.

——. *Malacothrix platyphylla* Gray. Proc. Am. Acad., vol. ix, p. 214, note. Lower valley of the Virgen; May.

No. 132. *Stephanomeria Thurberi* Gray, var. *nana*. Pl. Thurber, p. 325.

No. 133. *Lygodesmia exigua* Gray. Proc. Am. Acad., vol. ix, p. 217, note; fl. June.

No. 134. *Stephanomeria exigua* Nutt. Torr. & Gray, flora, vol. 2, p. 473.

No. 135. *Troximon aurantiacum* Hook. Fl. Bor.-Am., vol. i, p. 300, t. 104. Pine valley. June.

No. 136. *Calycoseris Wrightii* Gray. Pl. Wright. Part 2, p. 104, t. 14.

No. 137. *Malacothrix Torreyi* Gray. Proc. Am. Acad., vol. ix, p. 213, note; fl. April.

No. 138. *Rafinesquia Neo-Mexicana* Gray. Pl. Wright, part 2, p. 103; fl. April.

No. 139. *Microseris macrochæta* Gray. Proc. Am. Acad., vol. ix, p. 211, note.

No. 140. *Microseris linearifolia* Gray. Proc. Am. Acad., vol. ix, p. 211, note.

No. 141. *Perezia microcephala* DC. Dry rocky slopes near St. George; 2–3 feet high fl. June.

No. 142. *Encelia Californica* Nutt., var. (?).

THE INVERTEBRATE CAVE FAUNA OF KENTUCKY AND ADJOINING STATES.

BY A. S. PACKARD, JR.

I. ARANEINA.

In an article on the insects and crustaceans of Mammoth Cave, based on specimens obtained by Messrs. F. W. Putnam and C. Cooke, published in 1871 (American Naturalist, vol. 5), I expressed the hope that thorough zoological explorations of Mammoth Cave would be made by a state commission or by persons acting under the authority of the state. This hope has been fully realized. Since the publication of the "Mammoth Cave and its Inhabitants,"[1] the new geological survey of Kentucky has been instituted, under the charge of Prof. N. S. Shaler, who invited Mr. Putnam and myself to explore the caves of Kentucky under the auspices of the survey. Accordingly, during portions of the months of April and May, 1874, I examined Mammoth Cave and several adjoining, *i. e.*, White's Cave, Dixon Cave, Diamond Cave and Proctor's Cave, in company with Prof. Shaler and Mr. F. G. Sanborn, assistant on the survey, and subsequently Mr. Sanborn explored these and Carter caves. In company with Prof. Shaler, I also made a slight examination of the four Carter caves. Fully appreciating the importance of the subject of cavern life and of comparing the fauna of different caves, Prof. Shaler invited me to visit Wyandotte Cave, and the Bradford caves in Indiana. The Bradford caves I visited in company with Dr. John Sloan, of New Albany, Ind., who had already examined, with much success, many of the small caverns in southern Indiana. His observations on the temperatures of the caverns of his state are of much interest, and will be published in a succeeding paper. The collections made by him and contained in the Museum of Natural History of New Albany were also examined, and he has kindly sent me other material. On my return I examined Weyer's Cave and adjoining Cave of the Fountains near Staunton, Virginia, and discovered about twenty forms, where before none were known to inhabit

[1] By A. S. Packard, Jr. and F. W. Putnam, 8vo. pp. 62. With two plates and cuts. Salem, 1872.

those caves. In the autumn Mr. Putnam made a thorough exploration of Mammoth Cave. These papers are accordingly based on material collected by him, Prof. Shaler, Mr. Sanborn, Mr. Cooke, Dr. Sloan and myself.

Mr. Emerton kindly identified and described the spiders of the caves, and his paper and drawings accompany this article. The Coleoptera have been identified by Dr. LeConte, the Diptera by Baron Osten Sacken, and the only Neuropterous insect found, an immature Psocus, has been figured and identified, so far as it could be, by Dr. Hagen.

Without at this time speaking of the physical aspects of the caves, I may say that the life of the caverns is much more abundant than I had supposed from the accounts given by others. The spiders were found not infrequently in all the caverns mentioned in the notes appended to Mr. Emerton's descriptions. I should say that the spiders were equally abundant in Mammoth and Wyandotte caves, but they were most abundant in Weyer's, where three species occurred. They were next commonest in the Carter caves. These are small caverns, none more than a mile in extent; but it is interesting to observe that in Mammoth and Wyandotte caves respectively, both between five and seven or eight miles in extent, so far as rude measurements show, there was but a single species. The following table shows the distribution of the six species of true cave spiders:

MAMMOTH.	WYANDOTTE	BRADFORD.	CARTER.	WEYER'S.
Anthrobia mammouthia	Linyphia subterranea	?Nesticus Carteri.	Nesticus Carteri.	Nesticus pallidus.
			Linyphia subterranea.	Linyphia Weyeri.
			Linyphia incerta.	Linyphia incerta.

It will be seen that the two largest and consequently most ancient caverns, Mammoth and Wyandotte, and in which the physical environment of the species is most unvarying, have but one species each. The *Anthrobia mammouthia* is only found in Mammoth, and the small caverns, *i. e.*, Diamond and Proctor's, situated about five miles from it. No other species occurred in these smaller caves. The only spider found in Wyandotte Cave was the *Linyphia subterranea*, which also occurred in the Carter caves,

while in the Bradford Cave occurred a Nesticus thought by Mr. Emerton to be identical with *Nesticus Carteri.* The Carter caves and Weyer's caves are small caverns, all perhaps less than half a mile in length, with the exception of Bat Cave which is perhaps over a mile in length; the distances are uncertain, these caverns winding about very irregularly and their length is only estimated by guesswork.

It is in the small caverns of Carter County, Kentucky, and the two Weyer's caves (Weyer's and the adjoining Cave of the Fountains) which are often but a few (less perhaps than a hundred) feet below the surface, that the variation and number of species is greatest. In each set of caves there are three species, to one in Mammoth and Wyandotte caves. The individual variation was the greatest in *Nesticus pallidus*, and, as might be suspected, in the eyes. The degree of variation is indicated in Mr. Emerton's description.

The spiders occurred more abundantly in all the caves than we expected. The individual abundance was greater in the smaller caverns, especially the Weyer's caves, than any others. In the Mammoth Cave the Anthrobia occurred under stones in dry but not the driest places, on the bottom at different points in the cave. Sometimes two or three cocoons would be found under a stone as large as a man's head. The cocoons were orbicular, flattened, an eighth of an inch in diameter, and formed of fine silk, and contained from two to five eggs. They occurred with eggs in which the blastodermic cells were just formed, April 25th. The eggs were few in number and seemed large for so small a spider, being $\frac{25}{1000}$ inch in diameter. The chorion is very thin, and finely speckled. The blastodermic cells seemed very large, the largest measuring nearly $\frac{4}{1000}$ inch in diameter. They were round, not closely packed and showing no indications of being polygonal. They all had a dark, very distinct nucleus. I was unable to trace the development of the young, and ascertain if the embryos are provided with rudimentary eyes. Two young *Anthrobiæ* hatched out May 3d in my room. The whole body, including the legs is snow white, with the legs much shorter than in the adult. The adult in life is white, tinged with a very faint flesh color, with the abdomen reddish, in some specimens the abdomen has beneath several large transverse dusky bands. The *Linyphia subterranea*, as observed living in Wyandotte Cave, is pale pinkish horn brown on the thorax and legs, while the abdomen is dull honey-yellow.

What constitutes the food of these diminutive, weak, sedentary spiders, I cannot conjecture, unless it be certain minute delicate mites or young Poduræ. They spin no web, though some of the spiders in Weyer's Cave (Cave of the Fountains) do spin a weak, irregular web, consisting of a few threads. The Sciaræ and Chironomus are too large and bulky to be captured by them. The probable insufficiency of food as well as light, may account for their small size and feeble reproductive powers. The individuals were far less numerous than those of the Acanthocheir and Chelifers.

The distribution of Cave Araneina in the middle states, is paralleled by that of the other insects, as we shall see in subsequent papers. The other Arachnidans follow much the same law. So with the Myriopods. The *Spirostrephon* (Scoterpes) *cavernarum*, of Wyandotte Cave occurs abundantly in the Carter caves, but not in Mammoth Cave, which is so much nearer Wyandotte Cave. The common myriopod of Weyer's Cave, on the other hand, is closely allied to *Spirostrephon Copei*, but much less hairy.

I may here anticipate a fact which I shall bring out more fully in a subsequent paper and which has an important bearing on the derivative theory. I found in the Carter caves several specimens of *S. cavernarum* which were reddish-brown, and had apparently larger eyes than the normal white examples characteristic of the Carter and Wyandotte caves. I regard it as extremely probable that this reddish race has not been established long enough in the cavern to lose its original brown color. We here see, in fact, a cave species in process of formation, and I regard this as one of several facts which I hope to offer in subsequent papers, tending to prove that nearly all the cave animals are modified forms living at the present day out of doors. In all the caves examined, except Mammoth and Wyandotte, living Pulmonate mollusks occurred. The large dead snail shells I found on the banks of the river Styx in Mammoth Cave, must have been carried in dead by floods from the Green River or through fissures from above.

Every vegetable was carefully preserved. The common plant found in Mammoth Cave has been identified by Prof. Farlow as the old *Byssus aurantiaca*, now known under the name of *Ozonium auricomum* Link. Prof. Farlow, who kindly identified the cave plants, says that it is "found in caves on wood in Great Britain, Germany, etc., and has been found in Michigan and elsewhere by Schweinitz. As far as I know it is simply the mycelium of some

unknown fungus." A young Peziza occurred in Weyer's Cave, it was not in fruit, was colorless, and impossible to determine specifically. A colorless Agaric also occurred in Weyer's Cave.

The temperature of Weyer's Cave on May 18th, was 55°–56° Fahr. for both water and air; that of Zwingle's and Bat Cave (Carter caves) was ascertained by Prof. Shaler to be 48° for the water. Dr. Sloan ascertained the temperature of the brook in Bradford Cave to be 55° on May 9th. The temperature of Mammoth Cave is 59° the year around, according to Prof. B. Silliman. Mr. H. W. Conrad, proprietor of Wyandotte Cave, informs me that the temperature of Wyandotte Cave varies from 54° to 57° F.; that of Little Wyandotte Cave in April is 50°.

NOTES ON SPIDERS FROM CAVES IN KENTUCKY, VIRGINIA AND INDIANA.

BY J. H. EMERTON.

The collection of cave spiders contained about one hundred specimens of eleven species. Two species were found only about the mouths of caves. These are *Theridion vulgare* Hentz, a spider found all over the country in shady places, and a large species of Meta, which has been found in similar situations in Massachusetts and New Hampshire, and resembles *Epeira fusca* Blackwall. One young spider allied to Tegenaria was taken in Fountain Cave, Virginia, and four specimens of a species of the same family were found in small caves in Carter county, Kentucky; all were immature except one female, and none showed any subterranean characters. The remaining six species, all belonging to the *Theridiidæ*, were found in considerable numbers in the larger caves where there is little or no light and the climate is little affected by outside changes. One species of Linyphia from Weyer's Cave, Virginia, has the eyes of the normal size and number, and the colors and markings of some specimens are as bright as on spiders of the same family living in cellars or shady woods. The other five species are all pale in color and show some unusual condition of the eyes, three species having the front middle pair very small, one having all the eyes small and colorless,

with the front middle pair wanting in the males and some females, and one species being entirely without eyes. Following are descriptions of the last six species.

Nesticus pallidus n. sp.—Plate I. Figs. 22-27. Cephalothorax and legs pale orange-brown, abdomen yellowish-white with brown hairs. Length of female 3.5 mm. Cephalothorax 1.5 mm. long and nearly as broad, little elevated in front; three lines of hairs from the eyes to the dorsal pit. Front middle eyes black and half as large as the others, nearly touching each other. Rear middle eyes separated from each other by their diameter and from the front middle eyes by half that distance; lateral eyes in pairs separated from the middle eyes by half their diameter. Mandibles half as long as the cephalothorax. Maxillæ and labium short and wide. Palpal claw long and slender with six teeth along the middle. Legs 1, 4, 2, 3. 1st pair 10 mm., 2d 8.25, 3d 8.15, 4th 9.6, thinly covered with long hairs and without spines. Tarsal claws long and slender, the lower with two teeth. the upper with 9 or 10, Epigynum fig. 27; the sacs showing through the skin in some specimens. The only male taken had not finished moulting and was much distorted by the alcohol. The palpus which had cast its skin is shown in fig. 26, the penis is raised from its natural position, which is in a groove passing spirally round the end of the palpal organ to a fleshy conductor. A long process with two teeth at the end branches from the base of the tarsus.

Fountain Cave, next to Weyer's, Virginia, among stalactites where there was no daylight. Several loose cocoons were found, one containing thirty or forty young just hatched (Packard).

Nesticus Carteri n. sp.—Plate I, Fig. 28. Cephalothorax and legs light yellow, hairs shorter than in *N. pallidus*. Abdomen in some specimens with indistinct gray markings. Eyes smaller and farther separated from each other than in *N. pallidus*. Epigynum fig. 28. This species is otherwise much like *N. pallidus*. Bat Cave, Zwingle's Cave, Carter Co., Ky. (Packard). A cocoon collected by Mr. Packard, from Bradford Cave, Ind., contains young, which had passed their second moult, probably of this species.

Linyphia subterranea n. sp.—Plate I. Figs. 29-31. Cephalothorax and legs yellowish-brown, in some specimens reddish. Abdomen white with brown hairs, in two specimens from Zwingle's Cave gray with white spots. Eyes 8, fig. 30, white surrounded by a dark border, in one specimen colorless without dark borders. Front middle eyes very small and in the two dark specimens from Zwingle's Cave obscured by dark markings on the head. Mandibles with seven teeth in front of the claw grooves. Legs short 1, 4, 2, 3, spines on patella and tibia. Under claw of tarsus with two teeth, the upper claws with eight or nine. No claw on palpi. Epigynum external, as long as the maxillæ, extending backward along the under side of the abdomen (fig. 29-31) or when the abdomen is distended projecting out from it at a right angle.

Under stones in Carter and Wyandotte caves (Packard).

Linyphia Weyeri.—Plate I. Figs. 7-12. Cephalothorax and legs yellow-brown, abdomen from dark gray to white. Length of ♀ 2.25 mm. Cephalothorax wide and but little elevated in front in either sex. Front middle eyes near each other on a black spot, rear middle eyes separated by their diameter and by the same distance from the front middle eyes, lateral eyes in pairs, each pair surrounded by a black area and distant twice its width from the middle eyes. Mandibles long, spreading apart at the tips and inclined backward toward the maxillæ, beyond the ends of which they extend a third of their length in the female and farther in the male; 5 long teeth in front of the claw groove. No palpal claw. Legs 1, 4, 2, 3, first pair 4 mm. long in ♀ and 4.4 mm. in ♂, with two spines on femur, one on patella and two on tibia. Under claw of tarsus with one tooth, upper claws with nine or ten teeth. Epigynum with an oval opening behind, twice as wide as long, in front of which is a short, flexible appendage, fig. 11. Palpus of male, figs. 9 and 10. The tarsal process is a small hook on the upper side, the penis is long, and passes one and a half times round the palpal organ, supported through nearly its whole length by a wide thin conductor ending in a hard tooth. Under the end of the penis is a soft brush-like appendage, and beside it two hard processes.

Weyer's Cave, Virginia, in darkness, but not far from the entrance (Packard).

Linyphia incerta n. sp.—Plate I. Figs. 13–21. Length 2 mm. Cephalothorax and legs orange-brown, abdomen white with short, fine, brown hairs. Cephalothorax 1 mm. long and two-thirds as wide; in the male elevated in front, fig. 20, and furnished with longer hairs than in the female. Eyes small and colorless, and separated far from each other, figs. 18 and 21; the front middle pair are very small, hardly larger than the circles around the bases of the hair by which they are surrounded, and only distinguished from them by wanting the dark rim which surrounds the hair circles. In 5 females from Fountain Cave all the eyes are present, fig. 18; in one female one of the front middle eyes is wanting. In 3 males from the same cave both front middle eyes are wanting, as in fig. 21; in one male one only of the front middle pair is wanting. In 4 females and 1 male from Bat Cave, Carter Co., Ky., the front middle eyes are wanting. Mandibles long and spreading at the tips, inclined backward toward the maxillæ, seven teeth in front of the claw groove, which are longer in the males. No palpal claws. Legs 1. 4, 2, 3, longest 4.75 mm. Tarsal claws short and slender, under claw with one tooth, upper claws with 7 or 8 teeth. Spines on patella and tibia. Epigynum with a small oval opening behind with dark brown border. Palpus of ♂, fig. 17, having a sharply-curved process at the base of the tarsus. The penis is supported by a stout conductor nearly to its end where it passes a soft brush-like appendage.

Fountain Cave, Virginia, among stalactites in company with *Nesticus pallidus* (Packard), also in Bat Cave, Carter Co., Ky. (Shaler & Packard).

Anthrobia mammouthia. Plate I, Figs. 1–6. In 1844, Tellkampf described and figured roughly in Wiegmann's Archiv fur Naturgeschichte, several arthropods from the Mammoth Cave, among them an eyeless spider, which he referred with doubt to the Mygalidæ, apparently because he saw only 4 spinnerets. The eyeless spiders found by Dr. Packard in the Mammoth Cave in 1874 agree generally with Tellkampf's description, and his figure 13 represents quite well the outline of a specimen, flattened by pressure between two glasses. No other eyeless spider was found, and no other which could be identified with Tellkampf's description. There seems, therefore, little doubt that these are spiders of the same species as those described by Tellkampf. Adults, 1.5 mm. long, pale brownish-yellow, abdomen almost white with brown hairs, ends of palpi, palpal organs and epigynum reddish-brown. Cephalothorax with scattered hairs in front. No eyes. Mandibles with 4 long teeth in front of the claw groove. Maxillæ short and wide. Sternum wide and hairy. Legs 1, 4, 2, 3, longest about 2.5 mm., hairy, with spines on patella and tibia. Under tarsal claw with one tooth, the upper claws with 6 or more short teeth. No palpal claw. Palpus of ♂, fig. 3, with a long process on the outside of the tibia ending in a sharp hook. The tarsal process forms a small thin hook. Palpal organ very simple, the penis very short and accompanied by a soft, thin appendage. Spinnerets short, Hypopygium ½ the length of the first pair.

Mammoth Cave and Proctor's and Diamond caves, under stones (Sanborn & Packard). Small flat cocoons were found with some specimens, containing small numbers of eggs which were unusually large in proportion to the size of the spider.

[In this connection it may be of interest to learn the opinion of Dr. T. Thorell, the accomplished arachnologist of Upsala. Upon receiving a specimen of *Anthrobia mammouthia*, which I sent him, he writes me that "the Anthrobia if it really is the true *A. mammouthia* Tellkampf, scarcely differs from the genus Erigone by anything more than the want of eyes; it may, however, be added as a peculiarity, that the three long and slender tarsal claws are quite smooth, neither dentated nor pectinated. The species belong most certainly to the family *Theridiidæ*."

On the other hand on the receipt of a specimen of the same species of spider and from the same cave (Mammoth) as that from which the specimen was taken which was sent Dr. Thorell, M. Simon of Paris writes me that "the Anthrobia is not allied to *Mygalidæ*, as was supposed from the imperfect description of Tellkampf, but to our *Dysderidæ*, and the genus Leptoneta, only it is blind."—A. S. P.]

EXPLANATION OF PLATE I.

1. Anthrobia mammouthia ♀.
2. " " ♀, under side.
3. " " palpus of ♂.
4. " " ♀ side view.
5. " " front of head and mandibles.
6. " " foot of first pair.
7. Linyphia Weyeri ♂.
8. " " maxillæ and mandibles of ♂.
9–10. " " palpus of ♂.
11. " " epigynum.
12. " " foot.
13. Linyphia incerta ♂.
14. " " ♀ maxillæ.
15–16. " " palpus of ♂.
17. " " epigynum.
18. " " eyes of ♀ from Fountain Cave.
19. " " foot.
20. " " ♂ side view.
21. " " ♂ front of head and mandibles.
22. Nesticus pallidus ♀.
23. " " ♀ under side.
24. " " ♀ side view.
25. " " ♀ foot.
26. " " palpus of ♂.
27. " " epigynum.
28. Nesticus Carteri ♀ epigynum.
29. Linyphia subterranea ♀ under side.
30. " " ♀ front of head and mandibles.
31. " " ♀ side view.

LIFE HISTORIES OF THE MOLLUSCA.

BY A. S. PACKARD, JR.

I. LAMELLIBRANCHS.

HAVING gone thus far along the track leading from the moners to man, we come to where the road branches in several directions. The path from the Protozoa to the sponges, from the sponges to the polypes, and from the polypes to the Ctenophoræ, and through them to the Echinoderms, though at times devious and readily lost, yet in the retrospect is more easily followed than those lying before us. In fact there is no single track leading directly from the lowest to the highest animals. We have to follow distinct lines of development, and, after toiling up one ascent, find that it ends abruptly, without bringing us very near the goal. We then have to retrace our steps, return to the old fork in the road and essay a new path. For example, following up the line of mollusca, we come to the cuttlefishes with their well developed eyes and circulatory apparatus, nearly as complicated as those of fishes. If we follow the ascidian line of development, we trace immediately in their larval condition a *chorda dorsalis* and a relation of rudimentary organs which bear a striking analogy to those of Amphioxus, the lowest vertebrate. Again, in studying the Brachiopods, we follow a line of life which leads us to forms such as the Lingula which combines Annelid characters with remarkable features of its own. If after traversing these paths we take up the long and devious route which leads from the Rotifers through the non-segmented worms up to the leeches and Annelides, to the Crustacea and Insects, we shall then reach animals which in many respects are only inferior to the vertebrates, and in complexity of organization, in their morphology and in their psychological endowments, are on the whole, superior to any other invertebrates.

What is this initial point from which these lines diverge? It is a larval form having a bilateral, cylindrical body, sometimes annulated, divided into a preoral and postoral region, *i. e.*, a head and hind body, with a ciliated crown, often a whip-lash or tuft of bristles, with a mouth, a usually curved alimentary cavity, and anus opening often near the mouth. This stage is seen in the

young Echinoderm, such as the Auricularia or Bipinnaria; or in the Veliger state of the young mollusk; in the young worm, whether the "Actinotrocha" of the Sipunculus, or "Tornaria" of Balanoglossus, or "Mesotrocha" of a higher annelid, or even in the young Rotifers. For such a form the term *Cephalula* may be proposed in allusion to the fact that a cephalic region is indicated in this state, the Gastrula being a simple sac with the head end not differentiated from the opposite extremity. Let the reader compare the gastrula of the sponge (Fig. 49) with the Cephalula of the Trochus (Fig. 138, B) and he will detect the difference between the two stages. This stage is thus named simply to give emphasis to the fact that it is a form common at one stage in their life-history to several entirely different classes of animals, radiate, articulate and molluscan, independently of any theoretical considerations. I will only say that the Cephalula bears an analogous relation to these classes, as the Planula to the Radiates, the Nauplius to the Crustaceans, or the Leptus to the Insects.

We shall see in our future studies of the life-histories of the different classes of invertebrate animals, how often this Cephalula, with its ciliated crown, recurs.

No one has ever given a thoroughly satisfactory definition of the type of Mollusca, and we shall certainly not attempt one here. It may be said, however, that they are in their early stages, and in nearly all (except the Gastropoda, in which the visceral or abdominal end is asymmetrical), in adult life bisymmetrical animals bearing usually an external or internal shell (sometimes the shell is larval and deciduous), with the under lip converted into an organ of locomotion, the large fleshy foot. The nervous system consists of three pairs of ganglia usually surrounding the œsophagus, sending nerve-threads in irregular directions to the different organs.

The Mollusca usually have a well developed heart, more so than in the Crustacea and Insects, situated dorsally and consisting usually of a ventricle and two auricles. The respiratory organs depend or project from the mantle or tegument, and are permeated by a net-work of blood-vessels. A large number have an "odontophore" or "lingual ribbon, a band of teeth rolled up in the mouth. The mollusks are neither radiate nor segmented as in the Articulates or Vertebrates, though certain larvæ are indistinctly annulate as in that of Chiton.

For a further discussion of the characters of the mollusks as compared with the worms the reader is referred to Prof. Morse's memoir "On the Systematic Position of the Brachiopoda."[1]

The following tabular view of the mollusks is copied from Gegenbaur's "Principles of Comparative Anatomy." For further information the reader is referred to Woodward's "Manual of the Mollusca."

MOLLUSCA.

I. LAMELLIBRANCHIATA.
 1. *Asiphonia* (Ostræa, Anomia, Pecten, Mytilus, Arca, Unio).
 2. *Siphoniata* (Chama, Cardium, Cyclas, Venus, Tellina, Mactra, Solen, Pholas, Teredo).
II. CEPHALOPHORA.
 1. *Scaphopoda* (Dentalium).
 2. *Pteropoda.*
  Thecosomata (Hyalea, Cleodora, Chreseis, Cymbulea, Tiedemannia).
  Gymnosomata (Pneumodermon, Clio).
 3. *Gastropoda.*
  Heteropoda (Atlanta, Carinaria).
  Opisthobranchiata (Bulla, Aplysia, Doris, Glaucus, Æolis).
  Prosobranchiata.
   Cyclobranchiata (Patella, Chiton).
   Ctenobranchiata (Paludina, Neritina, Buccinum, Purpura, Murex, Fusus, Conus, Oliva, Strombus, Haliotis).
 4. *Pulmonata* (Lymnæus, Physa, Planorbis, Helix, Bulimus, Limax).
III. CEPHALOPODA.
 1. *Tetrabranchiata* (Nautilus).
 2. *Dibranchiata.*
  Decapoda (Spirula, Sepia, Loligo).
  Octopoda (Octopus, Argonauta).

Development of the Lamellibranchs. It is only within a comparatively few years that we have learned anything of the mode of growth of our commonest bivalve mollusks. To this day the life history of the common clam or quahaug is a mystery. The early stages of the oyster are only partially known. We know much less about the early stages of the common sea mussel; while the history of the fresh-water mussel (Unio) sketched roughly in 1831 by Carus, is still fragmentary. For the first definite knowledge of the metamorphoses of the Lamellibranchs, we are indebted to the distinguished Swedish observer Lovén, who gave between the years 1844 and 1849, a series of sketches more or less complete of

[1] Proceedings of the Boston Society of Natural History, Vol. xv, 1873, 8vo. pp. 60.

a number of marine forms. To him and to Sars, the famous Norwegian zoologist, who made the first sketch of the metamorphoses of the Gastropods, we are indebted for our earliest and most valuable facts in the life-history of the mollusks. Before this, some larval mollusks were regarded as infusoria by Ehrenberg.

Of the mode of development of the oyster, the lowest lamellibranch, the first information was supplied by Lacaze-Duthiers (1854–5), supplemented by the recent (1874) observations of Salensky. While some lamellibranchs, such as the Unio, are bisexual, the oyster is hermaphroditic. The eggs, which are yellow, after leaving the ovary are retained among the gills. A single oyster may lay 2,000,000 eggs. The spawning time of the oyster in Europe is from June to September. During their development the eggs are enclosed in a creamy slime, growing darker as the "sprat" (the term applied to the young oysters) develops.

The course of development is thus: after the segmentation of the yolk (morula stage), the embryo divides into a clear peripheral layer (ectoderm), and an opaque inner layer containing the yolk and representing the inner germinal layer (endoderm). A few filaments or large cilia arise on what is to form the velum or the future head. The shell then begins to appear at what is destined to be the posterior end of the germ, and before the digestive cavity arises. At this stage the two-layered germ is said by Salensky to represent the planula of the sponge. The digestive cavity is next formed (gastrula stage), and the anus appears just behind the mouth, the alimentary canal being bent at right angles. Meanwhile the shell has grown enough to cover half the embryo, which is now in the "Veliger" stage, the "velum" being composed of two ciliated lobes in front of the mouth-opening, and comparable with that of the gastropod larvæ. The young oyster, as figured by Salensky, is directly comparable with the Veliger of the Cardium (Fig. 121).

We have, then, three stages of growth in the oyster, (1) the morula, (2) the gastrula (with the digestive cavity as yet undeveloped and, (3) the veliger with an alimentary canal and a head and hind body (cephalula). This is an epitome of the mode of development of most of the lamellibranchiate mollusks whose embryology is known. Soon the shell covers the entire larva, only the ciliated velum projecting out of an anterior end from between the shells. In this stage the larval oyster leaves the mother and

swims around in the water, the cilia of the velum keeping up a lively rotary motion. In this state Lacaze-Duthiers observed it for forty-three days, without any striking change in form, except that the velum increased in size, and the auditory vesicle appeared, containing several otoliths, which kept up a rapid motion. But still the gills and heart were wanting. Of its further history we know but little, except that it becomes fastened to some rock and is incapable of motion. The oyster is said by the appearance of its shell, to be three years in attaining its full growth, but this statement needs confirmation.

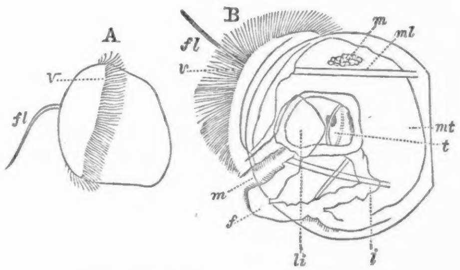
The most complete life history of a bivalve mollusk is that of Cardium (*C. pygmæum*), the cockle shell, as described by Lovén. The egg of this shell is spherical, the yolk being surrounded by a layer of white protoplasm, much as in the eggs of vertebrates. The process of fertilization was observed by Lovén, who saw the spermatic particles of the usual form, *i.e.* with a head and long tail, to the number of a dozen penetrating through the envelopes of the egg out toward the yolk. Following the morula condition the embryo consists of two layers, an outer peripheral clear mass like the "white" of an egg (ectoderm), and a central dark mass, regarded by later observers as equivalent to the inner germinal layer. The embryo now becomes ciliated on its upper surface and already rotates in the shell. On one side of the oval embryo is an opening or fissure,[1] on the edges of which arise two tubercles which eventually become the two "sails" of the velum. This probably represents the gastrula stage, and the embryo already shows a tendency to become bilateral. The next step is the differentiation of the body into head and hind body, *i.e.* an oral (cephalic) and postoral region. Out of the middle of the head grows a single very large cilium, like the whip-lash of the Flagellata, the so-called flagellum (Fig. 121 A, *fl*; *v*, velum). The shell (Fig. 121 B, *sh*) and mantle (*mt*; *ml*, muscle) now begin to form. From the inner yolk-mass are developed the stomach, the two liver lobes (*li*) on each side of the stomach (*t*), and the intes-

[1] This primitive opening, the mouth, appears both in Cardium and Crenella, according to Lovén's figures and descriptions, long before the shell begins to form. It is thus not a secondary formation, as Salensky insists, but a primary invagination of the ectoderm. The embryo is therefore properly a gastrula. It will be remembered that in the oyster on the contrary the shell begins to form before the mouth-opening appears. The young oyster at the stage immediately succeeding the morula is, then, a planula; the Cardium and Crenella, a gastrula. This exception does not warrant us in denying a gastrula state to the Lamellibranchs as a class, as Salensky does.

tine (i). The mouth (m), which is richly ciliated, lies behind the velum, the alimentary canal is bent nearly at right angles and the anus opens behind and near the mouth. The velum (Fig. 121, v) really constitutes the upper lip, while a tongue-like projection (Fig. 121, B f) behind the mouth is the under lip, and is destined to form the large impaired "foot," so characteristic of the mollusks.

In a stage previous to this, when the shell only partially covers the animal, the veliger may be compared with the veliger of Trochus (Fig. 138, B) and a remarkable resemblance be traced, the velum, the bent alimentary canal and the foot being almost identical. The shell arises as a cup-shaped organ in both bivalves and univalves, but the hinge and separate valves are indicated very early in the lamellibranchs. The earliest phase of the veliger stage

Fig. 121.



Development of Cardium. After Lovén.

(cephalula) indicated at Fig. 121 A, in which a cephalic and abdominal region is demarked, may be compared with profit by the reader with the embryo infusorian with its cup-shaped body and its crown of cilia, or with the larval Polyzoan or even the larval Brachiopod to be hereafter figured. At the stage represented by Fig. 121, B, the stomach is divided into an anterior and posterior (pyloric) portion. The liver forms on each side of the stomach an oval fold, and communicates by a large opening with its cavity; while the intestine elongates and makes more of a bend. The organ of hearing then arises, and behind it the provisional eyes, each appearing as a vesicle with dark pigment corpuscles arranged around a refractive body. The nerve ganglion (m) appears above the stomach. The two ciliated gill-lobes now appear, and the number of lobes increases gradually to three or

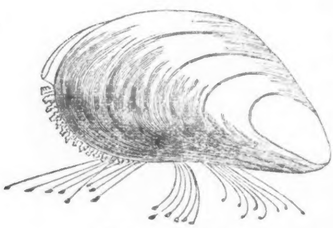
four. The foot grows larger, and the organ of Bojanus, or kidney, becomes visible. The shell now hardens; the mouth advances, the velum is withdrawn from the under side to the anterior end of the shell. In this condition the veliger remains for a long time, its long flagellum still attached, and used in swimming even after the foot has become a creeping organ. Latest of all appears the heart, with the blood-vessels.

Upon throwing off the veliger condition, the velum contracts, splits up and Lovén thinks it becomes reduced to the two pairs of palpi, which are situated on each side of the mouth of the mature Jamellibranch. The provisional eyes disappear, and the eyes of the adult arise on the edge of the mantle.

The mode of development of *Crenella marmorata* is nearly identical with that of Cardium. The Crenella is diœcious, the females being known by their reddish ovaries, the males by their white sexual glands. In this genus, however, there is no egg-capsule, and no "white" enveloping the yolk.

All that we know of the development of the common muscle (*Mytilus edulis*, Fig. 122, after Morse) is from studies made by Lacaze-Duthiers on the shores of the Mediterranean. The larval forms were not discovered. The young about $\frac{1}{5}$mm in length were found swimming at ebb tide on the surface of the water. The shell at this stage is like a Crenella, and there are four long gill lobes, which arise from the outer lamella of the inner gill.

Fig. 122.



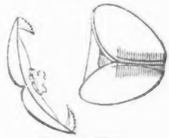
Common Mussel.

The fresh water bivalves pass through entirely different phases of development from the marine forms. The eggs of Cyclas have no shell, no "white" and no yolk skin; they are few in number, from one to six existing in unequal degrees of development in broad cavities filled with a nutritive fluid, and hanging free from the base of the inner gill. The velum is either absent or very slightly developed, and the shell begins to develop at two widely separated initial points on the mantle, according to Leydig.

The fresh water mussels (Unio, Fig. 123, after Morse, and Anodonta) represent another mode of development. In their embryo

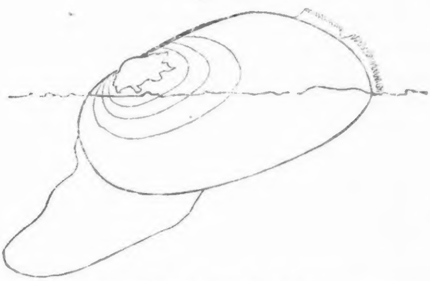
the velum is wanting or exists in a very rudimentary state. The mantle and shell are developed very early. They live within the parent fastened to each other by their byssus. The shell (Fig. 124) differs remarkably from that of the adult, being broader than long, triangular, the apex or outer edge of the shell hooked, while from different points within project a few large, long spines. So different are these young from the parent that they were supposed to be parasites and were described under the name of *Glochidium parasiticum*. They are found in the parent mussel during July and August. The eggs have a shell, "white," and yolk skin and a micropyle. The embryo rotates,

Fig. 124.



Young Unio.

Fig. 123.



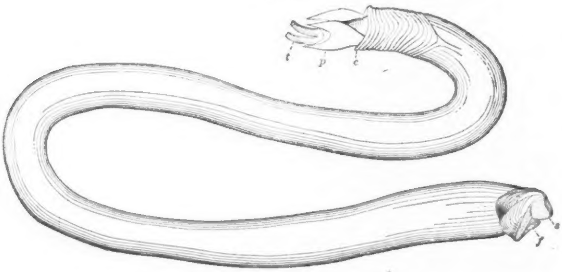
Unio moving through the sand with the siphons expanded.

and remains a month in the egg. When hatched, great numbers still remain among the gills in a mass of slime, and during this time the shell thickens, grows rounder and somewhat longer.

The history of the ship worm (Fig. 125, *Teredo navalis* Linn.) is one of great interest both from a practical and scientific point of view. To the eminent French naturalist, Quatrefages, we are indebted for its life history. Its general development up to the time of the larval stage is much like that of the oyster. The egg has no shell. After fertilization it undergoes total segmentation (Fig. 126, A). The two germinal layers appear as usual, the velum arises much as in the embryo oyster, there being no lash, as in the Cardium, but scattered cilia. Swimming about in this state the embryo would be mistaken for an infusorian. In forty-eight hours after life begins, the cilia begin to disappear and the germ

sinks to the bottom. A deep fissure now separates the germ into halves; meanwhile the mantle and shell have grown, and when

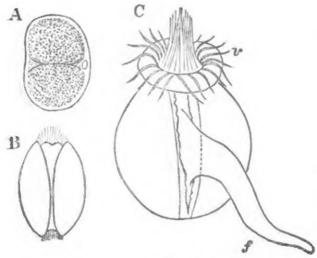
Fig. 125.



The Ship Worm.[1] After Verrill.

five days and a half old the germ appears as in Fig. 126, B, the shell almost covering the larva. Soon after this the velum becomes larger, and then decreases, the gills arise, the auditory sacs develop, the foot grows, though not reaching to the edge of the shell, and the larva can still swim about free in the water. When of the size of a grain of millet, it becomes spherical, as in Fig. 126, C, brown and opaque. The long and slender foot projects far out of the shell, and the velum assumes the form of a swollen ring on which is a double crown of cilia.

Fig. 126.



Development of the Ship Worm.

The ears and eyes develop more, and the animal alternately swims with its velum, or walks by means of the foot. At this stage Quatrefages thinks it seeks the piles of wharves and floating wood in which it bores and completes its metamorphosis. The further changes must be very great before it assumes the adult form of the ship worm with its long body, but these stages have not been observed. Keferstein, however, says that Vrolik saw in July the

[1] Fig. 125, *c*, collar; *p*, pallets; *t*, siphonal tubes; *s*, shell; *f*, foot. After Verrill. Report U. S. Fish Commissioner. Fig. 126, *v*, velum; *f*, foot. After Quatrefages.

larvæ swimming about on the coast of Holland, and some by the middle of the month had bored into the wood and attained the adult Teredo form, though still very small, while others in September still retained their larval, veliger shape. It requires about three weeks for them to complete their metamorphosis. Verrill states that the *Teredo navalis* on the coast of New England "produces its young in May, and probably through the greater part or all of the summer." Quatrefages says that the Teredos die during the winter succeeding their birth.

Keferstein tells us that some lamellibranchs attain their growth in one year. The fresh water mussels (Unio and Anodonta) are thought to live from ten to twelve years, while *Tridacna gigantea* probably lives from sixty years to a century.

The time of spawning usually takes place in summer. The edible mussel (*Mytilus edulis*) and different species of Venus are found with eggs and embryos among the gills from March till May, on the coast of Holland and France, while Pholas and Pandora and most other genera breed from July until September. On the Sicilian coast, according to Poli, Mya and Solen breed early in spring; Pholas, Chama, Venus, Donax, Anomia, Tellina and Mactra in summer; Mytilus edulis from October to December.

We have seen that the Lamellibranchs pass through a true veliger stage, and we shall soon see that their larval forms are directly comparable with the veliger state of most Cephalophora. In after life the "head" of the bivalve, *i.e.* the oral and preoral part of the body, which was fully half as large as the body in the veliger, diminishes greatly in size and importance, becoming finally merged with the postoral region and represented simply by the palpi and foot, the mouth-opening being situated at or near the extremity of the body, so that the old term Acephala well indicates the want of a cephalic region as compared with the large and well developed head of the snails (Cephalophora) and cuttle-fishes (Cephalopoda).

The summary of changes is usually as follows:

1. Egg fertilized by tailed spermatic particles.
2. Morula.
3. Gastrula. (Observed in a very few cases.)
4. Veliger (Cephalula). In Unio and Cyclas wholly or mostly suppressed.
5. Adult Lamellibranch.

LITERATURE.

J. E. Carus. Entwicklung von Unio und Anodonta. (Nova Acta Phys. Med. Leopold. 1831).

S. Lovén. Development of Marine Lamellibranchs. (Ofversigt af Kong. Vetensk. Akad. 1844–1849. Wiegmann's Archiv, 1849. See also Keferstein's abstract in Bronn's Classen und Ordnungen der Thierreichs, vol. iii.)

A. de Quatrefages. Anatomie et Embryologie de la Teredo. (Annales des Sciences Nat. 1848–50.)

Lacaze-Duthiers. Development of various Lamellibranchs. (Annales des Sc. Nat. 1854, 1855).

O. Schmidt. Entwickelung von Cyclas. (Müller's Archiv, 1854).

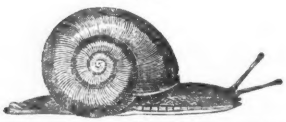
F. Leydig. Cyclas; Anatomie und Entwickelung. (Müller's Archiv, 1855).

W. Salensky. Bemerkungen über Hæckel's Gastræa-Theorie, with three drawings of the embryo oyster and very brief description. (Wiegmann's Archiv, 1874).

II. THE CEPHALOPHORA.

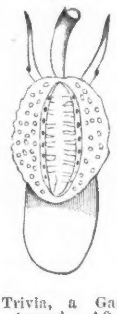
The Cephalophora include not only the Gastropods (snails and whelks) but more aberrant forms such as the swimming Pteropods

Fig. 128.



Helix in its natural position, creeping.

Fig. 127.

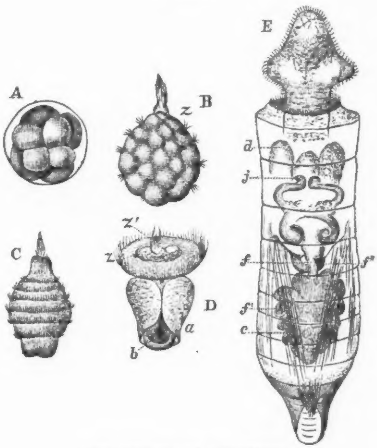


Trivia, a Gastropod. After Stearns.

and the Dentalium, etc. The term indicates the presence in the adult of a well formed head, as distinguished from the acephalous clams. Not only is there a head, but the eyes are restricted to the most anterior part of the preoral region, being, as in the snail, borne on extensile tentacles, whereas in the bivalves, such as the pecten, the eyes are scattered on the edge of the mantle along the entire body. The adult animal is not symmetrical, the mantle containing the viscera being thrown on one side. The foot is greatly enlarged, forming the entire under side of the animal, as in the snail (Fig. 128). The shell is usually external, spiral and asymmetrical, or cup-shaped.

The tooth shell, or Dentalium, is the lowest of its class, and its life history is one of much interest. For the following facts we are indebted to the memoir of Lacaze-Duthiers. The sexes are distinct. It breeds from the beginning of August until the middle of September. After fertilization by the spermatic particles, which Lacaze-Duthiers saw penetrating into the egg, the egg undergoes complete segmentation (A). At the end of this time the embryo swims about by means of tufts of fine cilia (Fig. 129, B), and a pencil of large cilia in front. It then lengthens and is provided with seven bands of cilia, and the larva is remarkably worm-like

Fig. 129.



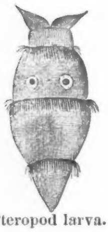
Development of Dentalium.

(C). When two days old the mantle secretes a small shell (a) at the end of the body. The ciliated bands now approach and form a swollen ring, or ciliated crown, the velum, as in fig. 129, D, z. At this time the shell is median, unpaired and situated on the back of the larva. The lobes of the foot next arise. Fig. 129, E, represents the young Dentalium, after leaving the larval state, and when thirty-five days old. The three-lobed foot protrudes from the shell now enclosing the animal, the rudimentary tentacles (E, d) are visible, as well as the subœsophageal nerve-ganglia (E, j) and the digestive canal (E, f, f'') and liver (f'). After this, the change into the mature form is slight.

The winged sea-snails (Pteropods) are beautiful creatures found floating on the high seas. With their large, ciliated velum and rudimentary foot they represent the Veliger or larval condition of the Gastropods. There is scarcely a more strikingly beautiful and strange object in nature than the Spirialis with its large heavily ciliated velum, which may be caught in our harbors with the towing net and compared with the young veligerous gastropods often captured in the same net.

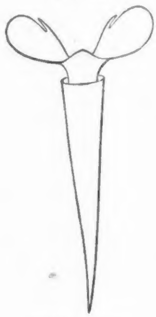
The egg of Cavolinia undergoes total segmentation, and before the large yolk-spheres are absorbed, the spherical embryo swims about like a larval infusorian with a crown of cilia. It may now be called a Trochosphere. Soon the larva assumes a conical form

Fig. 130.



Pteropod larva.

Fig. 131.

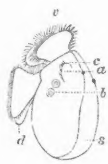


Styliola vitrea.

Fig. 132.

Æolis, a Nudibranch.

Fig. 133.



Larval Nudibranch.

and subsequently the velum greatly expands. Afterwards the Cavolinia, with its projecting foot, assumes a form much like the veliger of Trochus (Fig. 140, B). Fig. 130 (after Gegenbaur), represents a singular Pteropod veliger after the velum has disappeared, consisting of three distinct ciliated segments, like a worm. Fig. 131, after Verrill, represents an adult Pteropod, *Styliola vitrea*, enlarged three times, with the wings of the velum.

Bulla, Æolis and Doris, represent the Opisthobranchiate or naked mollusks, which either, as in the two latter genera, have no shell, with the gills arranged singly or in tufts on the back, or possess a white shell, as in Bulla, the bubble shell. Fig. 132 (from Verrill's Report, represents *Æolis*). Fig. 133[1] (after Schultze),

[1] Fig. 133, *d*, foot; *s*, nautilus-like deciduous shell; *v*, velum.

represents the young Tergipes, a naked sea-slug allied to Doris, with its large ciliated velum and foot, the animal being partly surrounded by a large shell (*s*). This shell is finally dropped with the other deciduous larval organs, the gills grow out from the back and the soft elongated body of the adult nudibranch, as this animal is called, is finally attained. It is a singular fact, discovered by Sars, that in the egg-capsules of Dendronotus, as many as six embryos develop side by side.

We will now more carefully study the course of development of a Bulla (*Acera bullata*) as given by Langerhans.

In this animal the yolk of the egg subdivides into two spheres of segmentation, one being much smaller than the other and differing in color. Each of these two cells subdivides into similar halves. The two larger cells then remain passive, while the smaller form a mass of nucleated cells which in two or three days form a layer surrounding the central, inactive yolk cells. On the fifth day arises the first indication of the shell, and on the same day is developed a furrow, the primitive mouth, which separates the cephalic end from the postoral extremity. On the seventh day appear the rudiments of the organ of hearing, and on the day after, the operculum. On the ninth day the pharynx, stomach and intestine begin to develop. On the fifteenth day the otolites are seen in the ear. The liver is next formed, and a few days after the eyes and nerve ganglia, when the larva hatches.

Fig. 134.

Veliger of Chiton.

With the mode of development of Chiton, a cyclobranchiate Gastropod, Lovén has made us acquainted. The larva leaves the egg oval in form, with a ciliated ring in the middle of the body and a long tuft of large cilia on the head. Afterwards it becomes annulated, as in Fig. 134 (after Lovén) and two eye specks appear. Its resemblance to a worm larva is now remarkable. It soon settles down into a quiet life as a Chiton (Fig. 135, *C. ruber*, represents a species found on our shores, from Verrill's Report, after Morse), and the limestone plates correspond to the primitive larval rings.

Fig. 135.

Chiton.

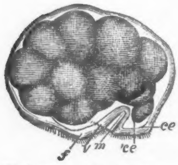
Of the mode of development of the other marine univalve shells (Prosobranchiate Gastropoda), I cannot do better than avail myself of the recent papers of Dr. Salensky. His studies were made

on shells living in the Black Sea, but we have species of Calyptræa and Trochus on our own coast.

Calyptræa sinensis lays its eggs in pear-shaped capsules attached to the same mussel or stone on which it lives. The young of the same brood develop at the same time. Development begins with the total segmentation of the yolk. After it divides into eight cells the blastoderm forms, which consists of a single layer of cells, the result of the subdivision of the first four spheres of segmentation, which grow over and envelop the yolk spheres, thus forming the two germinal layers (ectoderm and endoderm). The cells of the outer layer multiply and form the blastoderm, from which the skin, mantle and external organs, as well as the walls of the mouth arise, while, as in the articulates, the alimentary canal with its dependencies, the liver, etc., arise from the periphery of the yolk cells, the central mass being absorbed.

As soon as the blastoderm is formed, a heap of cells arise and the ectoderm pushes in at a spot which becomes the ventral side of the body. This is the primitive mouth. The anterior part of this cellular heap is the first indication of the "head-vesicle," which becomes a provisional organ well developed in the larva, and is also seen in the embryo fresh-water snails (Pulmonata). The sides of the primitive mouth form the two "sails" of the velum or swimming organ, so characteristic of the larval mollusks, and which was first noticed by Forskal, who wrote on animals just a century ago. Finally, the posterior edge of the infolding, which is also at first a little mass of cells, is the first indication of the foot. The whole surface of the embryo is now covered with cilia, and by their movement the embryo with its fellows, rotates in its capsule.

Fig. 136.



Veliger of Calyptræa.

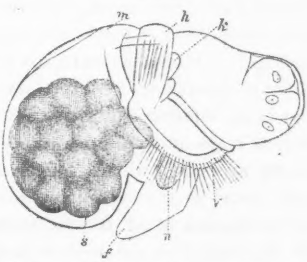
The next change consists in the growth and differentiation of the parts already sketched out. The germ of the foot extends backwards, the mouth-opening deepens and becomes tube-like, the first indication of the pharynx (Vorderdarm). The next most important change is the presence of a layer of cells between the outer and inner germinal layers, which is called the middle germ layer, with cells very unlike the outer layer, from which are developed the muscles of the foot and head as well as the heart

itself. Salensky thinks that this middle layer arises from the outer. It appears first on the ventral side of the embryo. The germ is now of the form indicated by Fig. 136 (*ce*, ectoderm; *'ce*, middle layer, the yolk spheres representing the inner layer, endoderm; *m*, mouth; *v*, velum; *f*, foot. After Salensky).

The next important chapter in the life history of the Calyptræa, is the appearance of the mantle, which arises as a disk-like thickening of the outer germ layer on the back of the embryo. In the middle of the disk the shell grows out as a cup-like cavity which is connected only around the edge with the mantle, but is free in the centre. The ears or auditory vesicles next appear, which, like the eyes, begin as an infolding of the outer germ-layer.

Up to this time the entire body has been symmetrical. Along the longitudinal axis of the body are the foot, the head-vesicle, the germ of the alimentary canal, and on each side a lobe of the velum. The alimentary canal, now further developed, begins to curve to the left, and as the shell grows, the visceral sack, or post-oral portion of the body, hangs over on one side. Not until the organs of sense appeared, the ears with their otolites, and the eyes with their pigment cells, did Salensky discover any trace of a nervous system, and then it was not the cephalic, but the ganglion of the foot which first arises as a mass of nerve cells from the ectoderm.

Fig. 137.

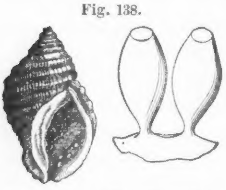


Veligor of Calyptræa farther advanced.

Fig. 137 (after Salensky) represents the asymmetrical larva with the shell enveloping a large part of the body, and the velum (*v*) and foot (*f*) well developed. The larval head forms a third of the whole body and is still finely ciliated. The temporary larval heart (*h*), a large oval vesicle, is situated on the right side of the back of the embryo, between the head and anterior edge of the mantle, in quite a different position from that of the adult heart, which afterwards arises as a new organ. The larval heart contracts rhythmically sixty times a minute. This is an entirely different organ, says Salensky, from the pulsating vesicle or "heart" seen by Duben and Koren in Purpura (Fig. 138, *P. lapillus* and egg capsules, from Verrill's

Report) and Buccinum, or the contractile vesicle found by Semper in Ampullaria, Cypræa, Murex and Ovulum, or the dorsal vesicle of the Pulmonates (snails). There is, however, a similar larval heart in Nassa.

Fig. 138.



Purpura and Egg Capsules.

At this stage also appears the primitive kidney (Fig. 137, *k*), also a deciduous organ, the permanent, adult kidney arising in another part of the body far behind the larval heart. It resembles the primitive kidneys of the snails (Pulmonates), and appears first as a sort of necklace consisting of four yellowish cells, situated next to the larval heart.

Meanwhile the more the posterior part of the body grows, the larger and more spiral becomes the shell, until the helmet shape of the adult is approached. At this stage also the gill-cavity appears, but there is as yet no trace of the gill itself.

In a succeeding stage the foot has increased in length, the spire of the shell has begun to topple over as it were and fall on one side like a skull cap, and now the adult heart (the pericardium being formed first), and permanent kidney and gills grow out. The gills originate from the ectoderm. It is not until this period that the end of the intestine and anal outlet is formed. The provisional larval organs now begin to disappear, the cephalic-vesicle (larval head) grows smaller, the primitive kidneys disappear. Of the larval visceral organs only the heart remains which, though smaller, still pulsates. It now rests under the mantle in the branchial cavity. There are now two gill-leaves, and finally the permanent heart is formed. The further changes consist in the perfection of all these organs and the development of the shell into the helmet shape of the adult. Fig. 139 (after Morse) represents the common *Calyptræa striata* of our own coast. We have seen that the usual five stages have been undergone, *i.e.* the egg, morula, gastrula (not so well marked as in the pond snail, Fig. 141), veliger and adult.

Fig. 139.

Calyptræa striata.

The metamorphoses of Trochus represent another type of development in the Gastropods, which illustrate points less clearly wrought out in the Calyptræa.

The eggs of *Trochus varius* are very small, spherical, and laid

in masses of jelly on sea weeds. The morula, or mulberry mass, forms as usual. The blastoderm arises from a few small clear spheres of segmentation situated at one pole of four primitive dark morula cells. The four vitelline or primitive cells, instead of remaining passive as in Calyptræa, subdivide, as well as the blastodermic cells. The egg now becomes flattened at one pole and slightly pointed at the other, the latter being the anterior end.

In six hours after development begins, the outer layer begins to form, and the first organ to arise is the velum, which at first consists of a swollen ciliated ring on the anterior end of the embryo. This stage (Fig. 140, A, *v*, velum, after Salensky) is equivalent to the trochosphere (Lankester) of the pond snail. It will thus be seen that the development of Trochus is now very different from that of the Calyptræa, where the velum, head-vesicle and foot arise simultaneously. A little later the mouth and œsophagus arise. Salensky remarks that the Prosobranchiate Gastropods as a rule develop like Trochus. In Vermetus, however, according to the observations of Lacaze-Duthiers, the velum does not arise in the form of a ciliated crown, but as a paired organ. Salensky adds, however, that in other respects there is a strong analogy in Calyptræa to Vermetus and Buccinum and Purpura, which develop like the former mollusk, having a similar larval heart and primitive kidneys, though the mode of development of the external organs is almost wholly unknown. There are thus five genera of Prosobranchiate Gastropods which develop as in Calyptræa, all belonging to the suborder Ctenobranchiata.

On the other hand, *Paludina vivipara*, *Neritina fluviatilis*, and certain Pteropods (*Tiedemannia neapolitana*, *Cavolinia gibbosa*) and a Heteropod (Pterotrachea) are provided, as in Trochus, with a ciliated crown, the first organ lying behind the primitive mouth.

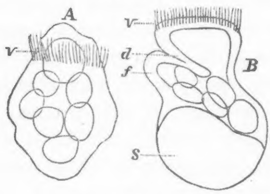
"A good starting point," adds Salensky, whom we have in reality been quoting all along, "for the comparison of the development of Trochus and allied forms, with that of other animals, consists in this stage (Fig. 140, A). A cursory glance at the illustration, will convince one that this condition of the Trochus embryo is similar to the larva of some annelides. Examples of such Annelid larvæ may be seen in some Sabellidæ (*e. g.*, *Dasychone lucullana*) or Spio (*S. fuliginosus*). The latter in escaping from the egg have a more or less oval body consisting of two layers, its only organ

a ciliated crown on the anterior part of the body. The idea of an analogy between the Mollusca and Annelid larva has already been suggested by Gegenbaur. Still more strongly does it follow from these facts, that in the Annelides, as surely as in the Mollusks, the mouth-opening, with the pharynx, arises immediately after the formation of the ciliated crown and somewhat behind the same. Immediately after the formation of the rudimentary pharynx arise the characteristic organs of the two types: in the Annelides the body segments with their appendages; in the Mollusks the foot, shell and two velar lobes."

Salensky then compares the development of Trochus with the Rotifer, Brachionus, and finds some striking analogies. His facts we shall present hereafter in describing from his memoir the life-history of a rotifer.

In the second period of development of Trochus the true Veliger state is entered upon. The mantle and shell are formed much as in Calyptræa. The body is now flattened, and the ciliated crown projects very slightly. The shell (*s*) has grown considerably.

Fig. 140.



Larval Trochus.

Fig. 140, B, after Salensky, represents this stage. The pharynx (*d*) arises through a tube-like invagination of the outer germ-layer, behind the ciliated crown (*v*). At the same time behind the mouth arises a projection, which indicates the beginning of a foot (*f*). Within the foot, as well as in the anterior part of the body, may be noticed the middle germ-layer, which arises as a layer of cells between the outer and inner germ-layer.

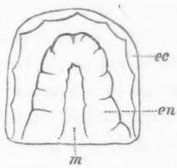
In the following stage the form of the larva is somewhat changed. The shell begins to unroll spirally on the under side of the body. The velum grows more than the middle portion of the head, and the lateral lobes become larger. The operculum also arises on the posterior portion of the foot.

Coming now to the mode of development of the Pulmonate mollusks (fresh-water and land-snails), we find that the aquatic orms undergo a complete metamorphosis, while in the land-snails there is no metamorphosis, and they are hatched in nearly the same form as the adult.

The life history, particularly the earlier stages, of the common pond snail (*Limnæus stagnalis*) of Europe has been worked out with much care by Prof. Ray Lankester, his observations confirming those of Lereboullet, Pouchet and others so far as they extended.

The eggs of Limnæus are deposited in June on the under side of water-plants, in capsules enclosing one, rarely two eggs, and surrounded by a mass of jelly. After segmentation the Gastrula (Fig. 141, *m*, mouth; *ec*, ectoderm; *en*, endoderm) is formed, the primitive digestive cavity or mouth resulting probably from an infolding of the ectoderm. Lankester believes that this orifice or mouth is temporary, the mouth of the adult being a later production. The primitive mouth closes as the embryo enters on the Veliger state, in the earliest stages of which the embryo is oval and surrounded by a ciliated ring, much as in the larval Trochus (Fig. 140, A). This state is called by Lankester the "Trochosphere." A definite Veliger stage is finally attained; the foot is large and bilobed, the mantle and shell then arise and the larva soon passes into the definite molluscan condition, with a shell, creeping foot, mantle-flap and eye-tentacles. The young snail hatches in about twenty days after life begins.

Fig. 141.



Gastrula of the Pond Snail.

Professor Lankester confirms the suggestions already made by Gegenbaur, Morse and Salensky regarding the resemblance of the larval mollusks to young worms. He remarks also that both the Trochosphere and Veliger forms are "well known and characteristic of various groups of Worms and Echinoderms, and the latter is seen in its full development in the adult Rotifera, and in the larval Gasteropoda and Pteropoda. The identity of the velum of larval Gasteropods, with the ciliated disks of Rotifera, seems to admit of little doubt, and it would be well to have one term, *e. g.*, velum, by which to describe both. The Trochosphere is the earlier, more or less spherical form in which the velum is represented by an annular ciliated ridge, and which is sometimes (*e. g.*, *Chiton*) provided with a polar tuft of long cilia.

"The cell, polyblast (morula), gastrula, trochosphere, and veliger phases of molluscan development are not distinctive of the molluscan pedigree; they belong to its præ-molluscan history. The foot, shell-gland, and the odontophore are organs which are

distinctively molluscan — the last characteristic of the higher Mollusca only — the other two of the whole group, and their appearance must be traced to ancestors within the proper stem of the molluscan family tree. The foot is essentially a greatly developed lower lip."

We would add that the Molluscan as well as Annelid Trochosphere may be directly compared (morphologically, not histologically) with the embryo Infusoria (see Fig. 33, E, p. 91) and the ancestry of the Mollusca as well as the Vermes should, as Haeckel declares, be traced back to the Infusoria, perhaps the parent-forms of the entire animal world above the Protozoa.

The usually hermaphrodite Cephalophora, as a rule, to sum up the different phases of their metamorphosis, pass through the following stages:

1. Egg.
2. Morula.
3. Gastrula. (sometimes suppressed?).
4. Veliger (the earliest substage being the Trochosphere, which passes into the generalized Cephalula form; or, restricted to the mollusks, the Veliger stage).
5. Adult mollusk, with foot, shell and often lingual ribbon (odontophore).

LITERATURE.

Sars. Development of Nudibranchs. (Wiegmann's Archiv. 1837, 1840, 1845).

Pouchet. Théorie positive de l'Ovulation spontanée, etc. Paris, 1847.

Leydig. Ueber Paludina vivipara (Siebold and Kölliker's Zeitschrift, 1850).

Koren and *Danielssen.* Bidrag til Pectinibranchiernes Udviklingshistorie. Bergen, 1851, 1856. (Wiegmann's Archiv, 1853).

Kölliker and *Gegenbaur.* Entwickelung von Pneumodermon. (Siebold and Kölliker's Zeitschrift, 1853).

Gegenbaur. Untersuchungen ueber Pteropoden und Heteropoden. Leipzig, 1855.

Claparède. Anatomie und Entwickelungsgeschichte der Neritina fluviatilis. (Müller's Archiv, 1857).

Lacaze-Duthiers. Histoire de l'Organization, du Dévelopment, etc., du Dentales. (Annales des Sciences Nat. 1858).

Lereboullet. Recherches d'Embryologie comparée sur le Dévelopment de la Truite, du Lézard et du Limnée. (Annales des Sciences Nat., 1862).

Salensky. Beitrage zur Entwicklungsgeschichte der Prosobranchien. (Siebold and Kölliker's Zeitschrift, 1872.)

Langerhans. Zur Entwickelung der Gastropoda Opisthobranchiata. (Siebold and Kölliker's Zeitschrift, 1873).

Lankester. Observations on the Development of the Pond Snail. (Quart. Journ. Microscopical Science, 1874.)

Consult also Keferstein, the author of vol. 3 of Bronn's Classen und Ordnungen der Thierreichs; 1862-66; and papers in different journals and transactions of Alder and Hancock, Carus, Krohn, Lacaze-Duthiers, Lovén, Müller, Reid, Schmarda, and Semper.

Development of the Cephalopods. Though the homologies of the Cephalopods with the Cephalophora, particularly the Pteropods, are quite direct, yet the cuttlefishes differ greatly in their mode of growth, particularly in the embryological stages. While the work of Kölliker on the development of the Cephalopods is a classic, yet I shall here avail myself in part of Ussow's more recent work. His observations, made at Naples, are based on two species of Sepia, Sepiola, Loligo and *Argonauta argo*, and they agree so well in their embryology, that the following description answers for all. In the partial segmentation of the yolk, Ussow, as Kölliker before him, was reminded of the same process in the eggs of birds and the turtle. It begins on one side of the yolk; a primitive furrow arising, which is intersected at right angles by a second furrow forming four divisions, afterwards eight, until finally a one-layered germinative disk (blastoderm) is formed on a portion of the surface of the egg, on the second day after development begins. The inner germ-layer then arises, which farther splits into two sub-layers (the outer of which is the dermo-muscular, and the inner the intestino-fibrous).

In Loligo and Sepiola by the 7th or 8th day the germ becomes perfectly spherical and ciliated in portions, so that it rotates in its sac.

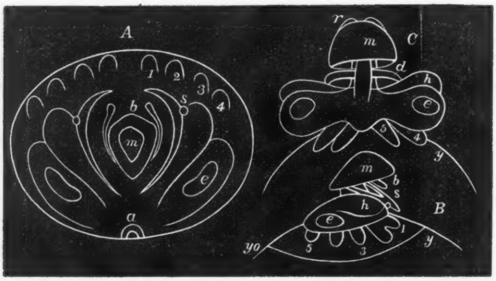
In the second period of development, that of the production of organs, the blastoderm covers the entire yolk. The mantle begins to form, next the rudiments of the eyes arise from the ectoderm, and the mouth appears. The embryo is now like a convex disk, or rather a hollow hemisphere.

On the 10th day the gills, funnel, arms and anal tubercle make their appearance, the germ of the gills arising from the dermo-muscular sub-layer of the middle germ-lamella.

On the 11th day the rudiments of the auditory organs, the pharynx and salivary glands arise, as well as the anal orifice, and on the succeeding day the auricles of the heart, the pericardium arising afterwards. The walls of the aorta and of the larger arteries and veins, with the offshoots of the latter (the so-called kidneys), are developed from the cells of the middle lamella, which become elongated and arrange themselves in rows. On the 13th day the ink-sac develops, and the liver. The intestinal tract originates from the primitive invagination of the outer germ-layer (ectoderm) as in Amphioxus, Ascidia, some Cœlen-

terates, the Brachiopoda, Vermes, etc. As to the mode of origin of the nervous system, Ussow says "I have been compelled to

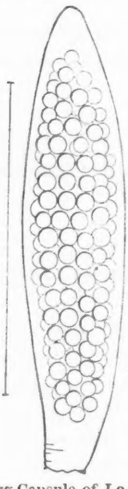
Fig 142.



Development of the Cuttle Fish.

give up forever the hope of finding any resemblance to its development in the Vertebrata, Tunicata, Annulosa and Mollusca."

Fig. 143.



Egg Capsule of Loligo Pealii.

All the ganglia of the Cephalopoda originate from more or less compact thickenings of the middle germ-lamella (dermo-muscular sub-layer), as in the peripheral ganglia of the vertebrates.

Ussow was unable to trace the origin of the genital glands, as they do not arise until after the animal is three days old, and he could not keep his specimens alive beyond this period.

Now returning to Kölliker's memoir for our information regarding the later stages, Fig. 142, A (*m*, mantle ; *b*, branchial processes ; *s*, siphonal processes ; *a*, mouth ; *e*, eyes ; 1–5 rudimentary arms, after Kölliker) represents the disk-like embryo resting on the surface of the yolk ; B, a side view of the embryo when farther advanced (*y*, yolk sack ; *h*, head), and C the same still older, the yolk sac still smaller, the contents having been partially absorbed. Soon after this the body and arms grow longer, and the animal moves about in its shell.

For our information regarding the still later history of our native cuttle fishes we are indebted to the observations of Prof. Verrill, from whose report on the Invertebrates of

Fig. 145.

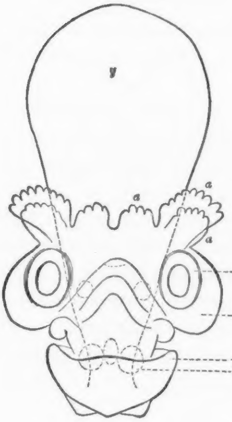


Fig. 144.

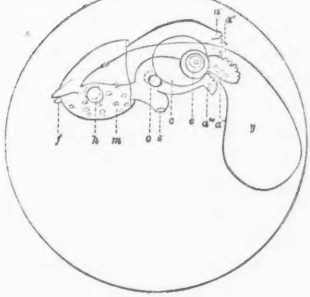


Fig. 146.

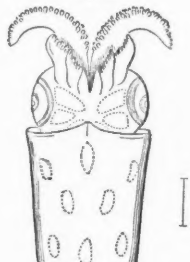
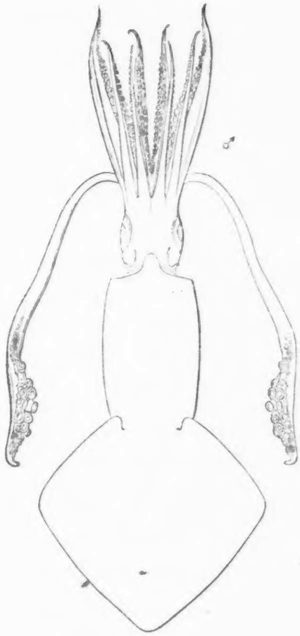


Fig. 147.

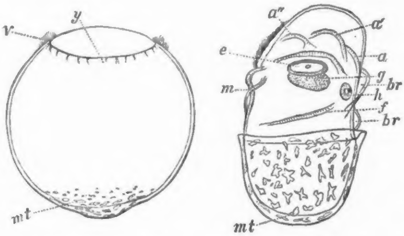


Development of a Cuttlefish. After Verrill.

Vineyard Sound in Prof. Baird's U. S. Fish Commission report these cuts are taken. Fig. 143 represents the egg-capsule of *Loligo Pealii*. Fig. 144[1] represents the young of the same cuttle fish, with the yolk sac (*y*). Fig. 145 represents the same farther advanced, while Fig. 146 gives an idea of the same after hatching, the yolk having been completely absorbed. Another species of cuttle fish (*Loligo pallida*) is represented by Fig. 147.

Such is the usual mode of development of the cuttle fishes. But in an unknown form probably over three feet in length, as its mass of eggs was thirty inches long, the mode of development is entirely different. The growth of the embryo is greatly accelerated, and immediately after segmentation it assumes a state analogous to the Trochosphere of other mollusca. To Grenacher's beautiful

Fig. 148. Fig. 149.



Development of an unknown Cuttlefish.

memoir we are indebted for the following facts regarding the life-history of this cuttle fish, whose adult form is unknown. He studied the eggs found floating in the Atlantic ocean, and was unable to raise it to maturity. After partial segmentation, the process being indicated by from five to eight radiating streaks, on the surface of the yolk, the embryo assumed the form indicated by Fig. 148, which represents the blastoderm growing around the under pole of the yolk mass and approaching the anterior end, where there is a swollen, ciliated band (*v*) apparently identical with the velum of the Trochosphere of the lower mollusca. This is an interesting point as Grenacher adopts Lovén's opinion that the arms of the Cephalopods represent and

[1] Fig. 144 *a*, *a''*, *a'''*, *a''''*, the right arms belonging to four pairs; *c*, the side of the head; *e*, the eye; *f*, the caudal fins; *h*, the heart; *m*, the mantle in which the color-vesicles are already developed and capable of changing their colors; *o*, the internal cavity of the same; *s*, siphon. The letters in Fig. 145 are the same (after Verrill).

are homologous with the velum of the lower mollusks, particularly the Pteropods, and not with the foot as commonly urged.

This spherical stage is also remarkable for the early appearance of the mantle, with the contractile pigment cells (chromatophores). It will be seen that the entire egg is, as in the lower mollusks, converted directly into the embryo. The embryo soon elongates, the mantle grows, the eyes and arms bud out, and the form of the adult is rapidly sketched out as in Fig. 149 (*m*, mouth; *a*, *a′*, *a″*, arms; *f*, inner and outer funnel-layer; *mt*, mantle, the dotted line ending in a chromatophore; *h*, ear; *g*, optic ganglion; *e*, eye.

We thus have in the embryology of this form, which seems not very different from Loligo (as may be seen in a more advanced stage figured by Grenacher not reproduced here), a mode of development much more like the lower mollusks than was before suspected.

Of the embryology of the fossil Tetrabranchiate Cephalopods (the Ammonites, etc.) we know from the beautiful researches of Professor Hyatt that the shell in Ammonites as well as Goniatites begins as a minute globular sac; in Nautilus this sac "is not retained, but traces of its former existence are apparent on the apex of the first whorl, in the form of a scar or cicatrix."

Summarizing the known facts regarding the living, dibranchiate Cephalopods, we have eggs and spermatic particles developed in separate sexes, the egg passing through the following phases.

1. Partial segmentation, analogous to that of Vertebrates.

2, *a*. Trochosphere (?) or germ developing on the surface of the yolk and gradually absorbing it; the Gastrula state suppressed; or, as is more usually the case (*b*), the adult form is directly attained.

LITERATURE.

Kölliker. Entwickelungsgeschichte der Cephalopoden. Zürich. 1844.

Hyatt. Embryology of the Tetrabranchiates. (Bulletin. Mus. Comp. Zool. 1872).

Lankester. Development of the Cephalopoda. (Annals and Mag. Nat. Hist. 1873, and Quart. Journ. Micr. Sc. 1875).

Grenacher. Zur Entwickelungsgeschichte der Cephalopoden. (Siebold and Kölliker's Zeitschrift. 1874).

Ussow. Zoologico-Embryological Investigations. (Annals and Mag. Nat. Hist. 1875).

Consult also the writings of Van Beneden, Metschnikoff, D'Orbigny, G. & F. Sanberger, Barrande and Verrill.

REVIEWS AND BOOK NOTICES.

THE HERPETOLOGY OF EUROPE.[1]—In this work we find the fullest list of European Batrachia and Reptilia which has ever been brought together. They are characterized by full descriptions, each of which is accompanied by an outline figure of the more essentially distinctive parts of the animal. As a manual for the determination of the species of European Reptilia, this work appears to be the most convenient in existence, providing the classification be not taken into account. It is also full in the matter of geographical distribution, supplying a want which has long been felt especially by extra European students.

Since the work is stated on the title page to be "Systematische Bearbeitung," it may be well to take a glance at the system adopt d. We find that the Batrachia are arranged in accordance with the system, or rather want of system, of fifty years ago. The important structural features which distinguish the crania of the salamanders, pointed out by Gervais, Gray and others, are not regarded as of sufficient weight to affect the classification. In consequence the genus Euproctus is united with Triton, and Geotriton with Spelerpes. The arrangement of the frogs and toads is still more remarkable. But one of the four genera embraced in the Pelobatidæ belongs to it, and this genus Pelobates embraces two well defined genera of authors. The typical species of one of these *Didocus calcaratus* is regarded as a synonyme of the very distinct *Cultripes provincialis*. Of the three remaining genera, two belong to the *Discoglossidæ*, the type genus of which, *Discoglossus*, is placed in the Ranidæ, a group which stands in the remotest relation to it consistently with reference to the same order. In the Anura as in the Urodela, osteological characters, the only reliable ones, are quite neglected.

Among the serpents we notice with regret the substitution of the time-honored Coluber by Callopeltis of later nativity, and Periops is scarcely different from Lamenis. The family characters are derived from the dermal scuta, which are quite inadequate for such serv ce. Characters of like inefficiency figure in the di-

[1] Herpetologia Europaea: Systematische Bearbeitung der amphibieon und reptilien w. in Europa aufgefundsind von Dr. Egir Schreiber, Brunswick, 1875.

agnoses of the families of Lacertilia, hence we find the Agamid genera referred to the Iguanidæ, and Opheomorus and Anguis to the Scincidæ!

The review of geographical distribution at the close of the volume is valuable in proportion to its completeness, which the date of the work in a measure guarantees. But with every appreciation of the value of the author's species work, the absence of systematic analysis deprives his book of the scientific merit which would otherwise belong to it.—E. D. C.

The Distribution of Insects in New Hampshire.[1]—The author, in this interesting essay, discusses with his characteristic thoroughness the relations of the faunæ (Alpine, subalpine, Canadian and Alleghanian) which have their representatives in that state. It is illustrated by a map of the state, showing the relations of the Canadian and Alleghanian faunæ, and another of the Alpine and subalpine regions of the White Mountains. The data are drawn from the butterflies and grasshoppers. We were not aware that such excellent material existed for such a full discussion of the subject, which will, we doubt not, greatly stimulate further studies on the geographical distribution of insects in this country.

Principles of Metal Mining.[2] — This is a compact, clearly-written and well illustrated little manual by a practical miner and member of the London Geological Society. The author has adapted it for the instruction of young miners starting in life. We have not met with a better and briefer introduction to the art of mining for the general reader.

BOTANY.

Fucus serratus and Fucus anceps. — I have received from Prof. A. F. Kemp, of Knox College, Galesburg, Ill., specimens of *Fucus anceps* Harvey, and *Fucus serratus* Linn., with the following notes concerning them which will be interesting to marine botanists.

---

[1] The Distribution of Insects in New Hampshire. A chapter from the first volume of the Final Report upon the Geology of New Hampshire. By S. H. Scudder. Concord, 1874. Royal 8vo. pp. 331-380. With two maps and a plate.

[2] Principles of Metal Mining. By J. H. Collins. Putnam's Elementary Science Series. With 76 illustrations. New York, G. P. Putnam's Sons. 12mo, pp. 149. Price 75 cents. For sale by A. A. Smith & Co., Salem, Mass.

I very much doubt whether *F. serratus* ever grew on our coast. I am not aware that any botanist has found it *in situ* or in such a condition as to warrant the belief that it was indigenous. In June, 1869, I found it in Pictou Harbor, Nova Scotia, but only in moderate quantity and attached to movable stones. It had all the appearance of being introduced from Europe, the European ships coming for lumber were accustomed, I was told, to discharge their ballast in the deep water of the harbor. This ballast, to my knowledge is often taken from the sea-shore. In this way I think the plant has been brought to this coast. It would be interesting to know whether the plant has been found anywhere else. Dr. Harvey's authority for assigning it to our coast is doubtful. * * *

At Peak's Island I found a form of *Fucus*, very abundant there but not noticed anywhere else. I sent it to Dr. Harvey who acknowledged it to be new to the Atlantic coast, and like a Fucus lately found in Ireland which he said was named "*Fucus anceps.*"

It grows very large, has the habit of *F. serratus* but wants the serratures. It grows just at low water mark and is never altogether free from the moisture of the sea. I have observed places north and south of Peak's Island, but have never seen a specimen anywhere else.

It looks so much like the young of *F. vesciculosus* that it is apt to be taken for it, which it certainly is not.

A specimen sent me by Harvey is much less robust than mine, very diminutive indeed but seems to have a like form.—D. S. JORDAN.

GENTIANA ANDREWSII.—In one of the numbers of the NATURALIST for 1874, some remarks were offered by a correspondent, regarding the fertilization of this species by humble bees. It was assumed since the stigma and its style also project some distance beyond the anthers, that this species needs the assistance of insects to become properly fertilized. The stigma is brought in contact with the pollen in the natural development of the flower. In the bud the epipetalous stamens and their cohering anthers are superior to the stigma. The latter is raised by the growth of both style and ovary, but especially the ovary, and pushed up through the ring of the cohreing anthers, but not until they have matured their pollen. This they shed so plentifully as to bury completely the stigma for the time being, and fertilize it even

more effectually than could possibly be done by humble bees in the manner suggested by your correspondent. Observation will fully establish the main fact of this statement.—M. W. Vausenburg, *Ft. Edward, N. Y., Apr.* 10, 1875.

Stenogramma interrupta.—In Grevillea for December, 1874, is an article by Mr. E. M. Holmes, "On *Stenogramma interrupta* Harv.," in which the writer states that Harvey had never published an account of the tetraspores of that plant, of which material had been sent him by Miss Gifford. In the "Nereis Amer. Bar.," Part II, p. 162, Harvey acknowledged the receipt of Miss Gifford's specimens, and gives a full account of the literature of this species, which is *Stenogramma interrupta* of Montague, not of Harvey as Mr. Holmes has it.—W. G. Farlow.

A Directory of American Botanists has appeared in the "Bulletin of the Torrey Botanical Club," New York. Also description of new fungi from New Jersey, with other notes of value to working botanists.

Preserving Fungi.—A good method for the preservation of Fungi is to place them in a solution of 1 part calcic chloride, 10 parts hydric oxide. This will change the phosphates in the fungus into phosphate of lime (calcic phosphate), after which they will be found to keep well.—J. H. Martin.

Volvox.—A work by Dr. F. Cohn on the developmental history of the genus Volvox has lately appeared.

North American Fungi.—The Rev. J. M. Berkeley continues his notices of our Fungi in "Grevillea."

ZOOLOGY.

New Phyllopod Crustaceans.—I have received from Dr. E. Coues, naturalist of the United States Northern Boundary Commission, a collection of these animals which he writes "occurred in myriads in several small prairie pools from a hundred yards to a half mile or so wide, exactly on the Boundary line, 49° N., just on the west bank of Frenchman River, Montana. You will not find this stream on the map, perhaps, by this name; it is one of the first of the whole series of similar streams flowing south into Milk River. The species was not observed elsewhere. The ponds were extensive shallow sheets of sweet water, of a comfortable

wading depth, generally with a little open space in the deepest part, but mostly choked with luxuriant vegetation (Gramineæ, Utricularia, etc.). Date of collection first week in July."

The occurrence of the Apus-like form, which may be called *Lepidurus Couesii*, is of much interest, as the genus has not before occurred on this continent south of the Arctic regions and Greenland, where *L. glacialis* occurs. Our western species, however, more closely resembles *L. productus* from Europe, but differs in the much longer telson, which is long, slender and spatulate. In this character, and its much longer carapace it differs from *L. glacialis* from Greenland. It also differs from *L. productus* in the eyes being closer together and more prominent.

In the males the carapace is a little shorter, and the telson twice as large as in the other sex, being three or four times as long as that of *L. productus*. Thirty-two males and thirty-one females occurred. This equality in the number of the sexes is noteworthy.

With these occurred a new Lymnetis with eggs. It is intermediate in size between *L. Gouldii* and *L. gracilicornis*, but more spherical than either. It may be recognized at once by the much produced, mucronate front, which in the two other species is broad and spatulate and square at the end. From this character it may be called *Lymnetis mucronatus*. Length .10-.13 inch.—A. S. PACKARD, Jr.

ARTIFICIAL HATCHING OF GRASSHOPPERS.—I recently noticed the hatching of grasshoppers under such peculiar circumstances that I thought them worthy of public mention. I was travelling with U. S. Troops in the southwestern part of Dacota Territory, through a region which had been visited by the flight of grasshoppers of 1874. It was January and the weather intensely cold. We generally came into camp each day at 4 P. M., when the snow was cleared off, tents pitched and fires lighted in them, which soon thawed out the ground and heated it for some distance around. The fire was not kept burning more than five hours at any camp, yet often the next morning young grasshoppers were seen skipping about as full of life as though they had not been subjected to such an unusual forcing process.—W. L. CARPENTER, *U. S. Army, Camp Robinson, Neb., Jan.* 17, 1875.

[It seems probable to us that the larvæ of the Caloptenus hatched in the autumn before the snow fell, as those of other and allied grasshoppers do in New England.—EDS.]

Dendroica dominica in Indiana.—Dr. Coues notices in the Naturalist for July, 1873, the occurrence of *Dendroica Dominica* Baird, "so far north" as Kanawha Co., West Va., as stated by Mr. W. D. Scott.

I shot in Indianapolis, Sept. 25, 1874, an individual of that species, apparently intermediate between the varieties *Dominica* and *albilora* as given by Baird, having the part of the superciliary stripe before the eye strongly tinged with yellow, and the yellow of the chin and maxillæ narrowly bordered next the bill with white.

Seiurus Ludovicianus Bp. I found last year about Green Bay, Wisconsin, in some abundance in the latter part of April.—D. S. Jordan.

The Whistling Swan.—A fine adult specimen of the whistling swan (*Cygnus Americanus*) was obtained on the 20th inst., by James Logan, near Shelbyville, in this state. It measured eighty-four inches from tip to tip of the wings. It was shot while feeding along a small stream of water in company with two others, one of which, from its brown color, was evidently young. The swan is exceedingly rare in this state, only stopping occasionally on its way to the North.—E. S. Crosier, *Louisville, Ky.*, *March* 27, 1875.

Habits of Snails.—A specimen of *Helix pomatia* lived for eleven months without feeding, and slept for seventeen weeks. Its weight was diminished by 0·13 gr., or 0·6 per cent. daily.—J. V. Sivers, C. B. Ver. Riga. (xix, p. 112), *Zoological Record for* 1872.

GEOLOGY AND PALEONTOLOGY.

Fossil Batrachia in Ohio.—Prof. J. S. Newberry, director of the geological survey of Ohio has made additional collections in the fossil-bearing coal-measures. Land vertebrate remains of that age have as yet been only found in Ohio within the limits of the United States, and the specimens are noted for their singularity and beauty. Thirty-three species of Batrachia have been found; but no reptiles nor higher vertebrata. One of the novelties is a species of the genus Ceraterpeton, the first time a European genus has been detected in this country. This form is as large as a rat, and has a pair of stout horns on the back of its head, in the posi-

wading depth, generally with a little open space in the deepest part, but mostly choked with luxuriant vegetation (Gramineæ, Utricularia, etc.). Date of collection first week in July."

The occurrence of the Apus-like form, which may be called *Lepidurus Couesii*, is of much interest, as the genus has not before occurred on this continent south of the Arctic regions and Greenland, where *L. glacialis* occurs. Our western species, however, more closely resembles *L. productus* from Europe, but differs in the much longer telson, which is long, slender and spatulate. In this character, and its much longer carapace it differs from *L. glacialis* from Greenland. It also differs from *L. productus* in the eyes being closer together and more prominent.

In the males the carapace is a little shorter, and the telson twice as large as in the other sex, being three or four times as long as that of *L. productus*. Thirty-two males and thirty-one females occurred. This equality in the number of the sexes is noteworthy.

With these occurred a new Lymnetis with eggs. It is intermediate in size between *L. Gouldii* and *L. gracilicornis*, but more spherical than either. It may be recognized at once by the much produced, mucronate front, which in the two other species is broad and spatulate and square at the end. From this character it may be called *Lymnetis mucronatus*. Length .10–.13 inch.—A. S. PACKARD, JR.

ARTIFICIAL HATCHING OF GRASSHOPPERS.—I recently noticed the hatching of grasshoppers under such peculiar circumstances that I thought them worthy of public mention. I was travelling with U. S. Troops in the southwestern part of Dacota Territory, through a region which had been visited by the flight of grasshoppers of 1874. It was January and the weather intensely cold. We generally came into camp each day at 4 P. M., when the snow was cleared off, tents pitched and fires lighted in them, which soon thawed out the ground and heated it for some distance around. The fire was not kept burning more than five hours at any camp, yet often the next morning young grasshoppers were seen skipping about as full of life as though they had not been subjected to such an unusual forcing process.—W. L. CARPENTER, *U. S. Army, Camp Robinson, Neb., Jan.* 17, 1875.

[It seems probable to us that the larvæ of the Caloptenus hatched in the autumn before the snow fell, as those of other and allied grasshoppers do in New England.—EDS.]

Dendroica dominica in Indiana.—Dr. Coues notices in the Naturalist for July, 1873, the occurrence of *Dendroica Dominica* Baird, "so far north" as Kanawha Co., West Va., as stated by Mr. W. D. Scott.

I shot in Indianapolis, Sept. 25, 1874, an individual of that species, apparently intermediate between the varieties *Dominica* and *albilora* as given by Baird, having the part of the superciliary stripe before the eye strongly tinged with yellow, and the yellow of the chin and maxillæ narrowly bordered next the bill with white.

Seiurus Ludovicianus Bp. I found last year about Green Bay, Wisconsin, in some abundance in the latter part of April.—D. S. Jordan.

The Whistling Swan.—A fine adult specimen of the whistling swan (*Cygnus Americanus*) was obtained on the 20th inst., by James Logan, near Shelbyville, in this state. It measured eighty-four inches from tip to tip of the wings. It was shot while feeding along a small stream of water in company with two others, one of which, from its brown color, was evidently young. The swan is exceedingly rare in this state, only stopping occasionally on its way to the North.—E. S. Crosier, *Louisville, Ky., March* 27, 1875.

Habits of Snails.—A specimen of *Helix pomatia* lived for eleven months without feeding, and slept for seventeen weeks. Its weight was diminished by 0·13 gr., or 0·6 per cent. daily.—J. V. Sivers, C. B. Ver. Riga. (xix, p. 112), *Zoological Record for* 1872.

GEOLOGY AND PALEONTOLOGY.

Fossil Batrachia in Ohio.—Prof. J. S. Newberry, director of the geological survey of Ohio has made additional collections in the fossil-bearing coal-measures. Land vertebrate remains of that age have as yet been only found in Ohio within the limits of the United States, and the specimens are noted for their singularity and beauty. Thirty-three species of Batrachia have been found; but no reptiles nor higher vertebrata. One of the novelties is a species of the genus Ceraterpeton, the first time a European genus has been detected in this country. This form is as large as a rat, and has a pair of stout horns on the back of its head, in the posi-

tion and having much the form of those of the ox. The skull is sculptured by rows of small pits, separated by fine radiating ridges.— *Independent.*

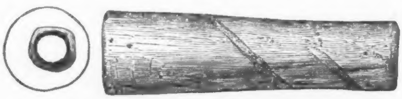
THE PROSPECT OF VOLCANIC ERUPTIONS IN THE WEST seems to be good if the opinions of the geologists of Wheeler's Expedition are correct. "In the past they have occurred so recently that it is, indeed, surprising that there is no human record of them," and eruptions may take place at any time in the future. In Southern Utah they ascertained that there are connected floods of lava covering an area of 5,000 square miles, while in Arizona and New Mexico there is an area not less than 20,000 square miles in extent, and never before recognized as a connected belt.

GLACIAL PHENOMENA IN UTAH.—The southern limits of the ancient system of glaciers has been ascertained by the geologists of Wheeler's Survey, through the entire extent in longitude of the Survey, and an attentive examination has been made of the record of an expansion of Great Salt Lake, which occupied the valleys of Utah, while the highest mountain gorges were choked with ice.

ANTHROPOLOGY.

CLAY "HUNTING-WHISTLES."—There occasionally occurs among the relics of central New Jersey, found upon the surface, short, cylindrical tubes of fire-baked clay, measuring from one and one-half to two inches in length, slightly tapering, being half an inch or slightly larger at one end, and about three-eighths of an inch at the smaller end. These tubes I have always considered as

Fig. 150.



simply pipe-stems, and such, in fact, they may be; but two facts connected with them, now suggest the possibility of their having been utilized as whistles (?). Every specimen met with has been very carefully squared at the end which joined the bowl of the pipe, if the specimens are pipe-stems, showing that they were utilized after the fracture occurred. Considering, however, the great abundance of fragments of clay pipes, it seems strange that

no broken stems, *not smoothed* at the broken end should be found. Split stems, and fragments of bowls are met with, and occasionally an entire pipe. The specimen figured (150) giving a good idea of the whole series as found by me, was taken from an "Indian" grave, associated with the usual "find" of relics so occurring. This fact seems to indicate that whether utilized pipe-stems or implements *de novo*, they had some special use; and I suggest that such use was as whistles. By placing the thumb over the basal or larger opening, and holding the specimen at right angles to the lips, it requires but a slight blowing effort to make a remarkably shrill clear whistling, which can easily be heard a quarter of a mile. In the hands of the aborigines, accustomed to their use, no doubt a much shriller "call" could be made with them. Of course the whole matter is an undeterminable one, but I suggest this as a plausible explanation of the presence of considerable numbers of this peculiar relic.—CHARLES C. ABBOTT, M. D., *October*, 1874.

THE BRONZE AGE IN SWITZERLAND.—The Memoirs of the Society of Natural Sciences of Neuchâtel (Tome. iv, part 2), contains a beautifully illustrated memoir on the bronze age in Switzerland, especially of the Lacustrian inhabitants.

MICROSCOPY.

A SECTION CUTTER FOR HARD OBJECTS.—Dr. George Hoggan's section machine, as described at the Queckett Club, differs radically from the tubular style of section cutters in common use. According to the inventor's assurance, which is fully justified by the appearance of his contrivance, he had at the time of its construction never seen a section cutter of any kind, and to this fact he attributes the originality of his conception. The object to be cut, instead of being packed in a tube, is (protected by slices of carrot or pieces of paper) fastened by means of a clamp and binding screw upon a sliding support or "table" which is moved in a grooved track at right angles to the course of the saw or knife by a screw capable of giving a graduated motion of $\frac{1}{500}$ inch. On each side of this sliding table, and attached to the bed-plate on which it slides, is an upright guide-bar to serve as a lateral support for the instrument making the sections. Hard sections, as of bone, are cut with a fine saw, what is called the "Pearl saw" being the best, which, like all other saws, should in Dr. Hoggan's

opinion, be mounted so as to cut during the pulling and not during the pushing stroke. The saw cuts sections of bone at the rate of one in two to three minutes, which are sufficiently thin and smooth, and only require to be washed free from sawdust to be ready for mounting. The saw frame being thicker than the blade, the upper part of each of the guides is set back so that the blade and frame of the saw will both move in the same perpendicular plane. Both blade and frame are held against the guides by steel springs, the face of the guides being also protected by hardened steel, securing a correct path for the saw independently of the skill of the operator. For cutting soft tissues, with a razor, the instrument is turned so that the cutting is done in a horizontal instead of a vertical plane, the object being arranged on the sliding table by means of a tray. The cavity most convenient for ordinary work will contain a $1\frac{1}{2}$ inch cube of the material to be cut, though it may be so enlarged as to permit the cutting of a section of 4×6 inches.

Recent Objectives.—Mr. Charles Brooke in his President's Annual Address before the Royal Microscopical Society, makes some interesting suggestions in regard to last year's improvements in object glasses. A "remarkably fine $\frac{1}{8}$th" by Powell & Lealand, with an avowed single-front lens is mentioned, but its principle of construction is not discussed, as it has not been made known by its makers.

Increased flatness of field has been obtained in objectives constructed on Mr. Wenham's formula, by replacing the original single plano-convex posterior lens by two plano-convex lenses of proportionally less curvature. Mr. Brooke possesses a $\frac{1}{7}$th thus improved, which excels in definition any other objective in his possession. It defines well with the sixth eye-piece of Ross, which however, he would never think of using except as a test of definition.

The fog which is so conspicuous a defect in some otherwise excellent glasses, he suggests may be partly due to the multiplication of cemented contact-surfaces, and that it may be so excessive in certain cases because of increasing not in the simple ratio of such surfaces, but in proportion to the square of that number, as if an objective with four cemented surfaces should have four times as much fog as one with two such surfaces.

Personal Equation in Microscopy.—The "Monthly Microscopical Journal" gives the following excellent summary of Mr. Ingpen's interesting communication on the above subject to the Queckett club:—

"Mr. Ingpen communicated some notes on 'Personal Equation,' with reference to microscopy. He first explained the use of the term in astronomy, as exemplified in transit observations, and in its more extended differences by a constant quantity between observers, short of actual defects of vision. The same causes affected microscopical observation, though they were not so well recognized as in astronomy. The principle points referred to were the following: I. *Mental* equation, as causing differences in interpretation, particularly with regard to test-objects. II. *Nervous* equation, as shown by varied sensibility to tremors, etc. III. *Color.* Difficulty in estimating color, as noted in Admiral Smyth's 'Sidereal Chromatics.'—Right and left eye often differ in this respect.—Effect of yellow crystalline, referred to by Professor Liebreich in his lecture on 'Turner and Mulready.'—Difference in visibility in violet end of the spectrum, amounting in some cases to slight fluorescence.—Effect of red and yellow grounds in increasing definition in certain cases.—Effect of bluish mist caused by slight opacity of cornea or crystalline upon estimation of the correction of objectives.—Color blindness often existing in a slight degree unsuspected, and difficult of detection. IV. *Focal equation.* Differences in effect of long and short sight upon cover correction, etc., also upon depth of focus, and power of resolving surface markings.—Differences in size of images formed by right and left eye, and consequent effect upon binocular vision.—Want of accommodation, and pseudoscopic vision, etc. V. *Form.* General tendency of the eye to show ultimate particles circular.—Effect of square and triangular apertures.—Effect of astigmatism upon form, particularly of lines and dots, as seen in different directions.—Reference to Professor Liebreich's lecture.—Effects of diffraction upon points of light, etc.—General considerations of the effects of unnoticed differences of vision producing discrepancies often attributed to other causes."

The microscopists seem no more agreed than other critics, as to the peculiarities of the later Turner pictures, as "Mr. J. G. Waller differed from Mr. Ingpen with reference to the later pictures of Mulready, which Professor Liebreich considered to show the effect of yellow crystalline; and gave reasons for thinking that the blueness of those pictures was due to their unfinished condition. He thought also that Turner's later pictures showed extravagant mannerism which could be thrown aside at will."

Pigment-Particles.—Dr. J. G. Richardson's suggestion that particles of dried blood which washing has failed to remove from

the irregular surface of previously used glass slips or covers have been habitually mistaken for recent objects and have become familiarly recognized as pigment-particles, is discredited by Mr. Brooke, who does not believe such a theory applicable to the work of experienced microscopists.

NOTES.

Mr. R. U. Piper in an article in a daily paper on the use of Paris green in killing potato beetles, warns people against its use as it is a deadly poison. A single grain is sufficient to cause death, and a little of the dust received into the system from time to time is extremely dangerous. M. de Kerchove also deprecates the use of the arsenite of copper (Scheele's or Paris green) as too dangerous a substance to be made common. Its careful use during the coming season should be inculcated.

Sir Charles Lyell has bequeathed $10,000 to the Geological Society of London, "for the encouragement of geology, or of any of the allied sciences by which they shall consider geology to have been most materially advanced, either for travelling expenses, or for a memoir or paper published or in progress, and without reference to the sex or nationality of the author, or the language in which it may be written."

Dr. Hofmann, of Berlin, recently delivered the Faraday Lecture of the Chemical Society at London. At a dinner, when one hundred and eighty scientists were present, "probably," says "Nature," one of the most remarkable scientific dinners that have taken place for some years, he made a noble appeal in behalf of the recognition of the high value of pure scientific research.

Dr. Steindachner recently read a paper before the Imperial Academy of Sciences at Vienna, on the river fishes of the south-eastern coast district of Brazil, from the mouth of the La Plata to that of the San Francisco.

Daniel Hanbury, the joint author (with Dr. Flückiger) of a late work entitled "History of Drugs" died March 24th, aged 49. He was an F. R. S. and treasurer of the London Linnæan Society.

Dr. H. R. Goeppert, the venerable professor of botany at Breslau, celebrated the fiftieth anniversary of his graduation, Jan. 11th.

Acting-Governor Van Zandt has appointed George H. Wilson member of the commission to prepare plans for a geological and scientific survey of the State of Rhode Island, in place of Hon. Rowland Hazard, declined.

Prof. M. Foster and A. G. Dew-Smith lately read a paper before the Royal Society "On the behavior of the hearts of mollusks under the influence of electric currents."

Prof. Asa Gray, at a meeting of the French Academy held on the 16th March, was elected an honorary member in the department of science.

Just as we are going to press, we learn that the bill for the scientific survey of Massachusetts failed to pass the House, but the vote (nearly a tie vote) in its favor was so large as to indicate that public sentiment strongly demands a resurvey of the state. The movement in Massachusetts has extended to Connecticut and Rhode Island, while the recently published report of Prof. Hitchcock, as state geologist of New Hampshire, is a credit to that state. We look confidently to the institution, within the next year or two, of resurveys of nearly all the New England states.

It seems that our paragraph taken from a Swiss paper regarding the block of granite designed to cover the grave of Agassiz, contained some errors. The bowlder in reality came from the terminal moraine. Judging from its position when removed, it must have formed part of the median moraine, and have been about 7,000 feet higher up where Agassiz lived on the Aar glacier. It probably came originally from the "Abschwung."

The University of Wisconsin at Ann Arbor has received an appropriation of $80,000 from the legislature for building a Science Hall.

We have received from Mr. C. F. Dennet an interesting pamphlet entitled "Vegetable Fishes," with special reference to the textile fibres, etc.

The fifth volume of the Annals of the "Museo Civico" of Genoa is devoted to an elaborate memoir on the birds of Borneo, by Salvadori, of Turin.

A propeller has been invented to imitate the action of the dorsal undulating fin of the pipe fish and sea-horse. — *Nature.*

The Signal Service office at Washington, is to publish in its weather reports, the more apparent phenological phenomena, *i. e.*, the times of flowering of plants and appearance of animals in the United States.

It seems that a species of Peronospora, the same genus of fungi as that which occasions the potato rot, infests the opium crop of India very seriously, causing the blight.

ANDERSON SCHOOL OF NATURAL HISTORY, SESSION OF 1875.

Owing to the impossibility of carrying on the Anderson School of Natural History at Penikese, on the same terms as formerly, the trustees have decided to charge a fee of fifty dollars for the coming session. The price of board will be fixed at the lowest possible terms. The course of study, for the season of 1875, will be announced at an early date. It is very desirable that application for admission be made at once to the director. Preference will be given to teachers.—Alexander Agassiz, Director. *Cambridge, April* 20, 1875.

BOOKS RECEIVED.

An essay concerning Important Physical Features exhibited in the valley of the Minnesota River, and upon their signification. By G. K. Warren. Washington, 1874. pp. 22. 8vo.

Report of the Commissioner of Education, 1873. Washington, 1875. pp. 1048. 8vo.

Bulletin de la Societe Geologique de France. Paris, IIIe Serie, Tome 1. Nos. 1-5, 1873. Tome II. Nos. 1-6, 1874. Tome III, Nos. 1, 2, 1875. 8vo. *Reunion Extraordinaire a Raonne.* Aug. and Sept. 1873 8vo.

Geological Survey of Alabama, Report of Progress for 1874. By Eugene A. Smith. Montgomery, 1875. pp. 139. 8vo.

Geological Survey of Canada, Report of Progress for 1873-74. Montreal, 1874. pp. 268. 8vo.

Proceedings of the Academy of Natural Sciences of Philadelphia. 1875. pp. 153-266. 8vo.

Quarterly Journal of Microscopical Science. London, Oct. 1874. pp. 323-430, Jan. 1875. pp. 106. 8vo.

Sitzungsberichte der physikalisch-medicinischen Societat zu Erlangen. Erlangen, 1874. pp. 177. 8vo.

Jenaische Zeitschrift fur Naturwissenschaft. Jena, 1874. VIII Bd. N. F. I., Bd. 3. pp. 337-480. 8vo.

Vegetable Fibres, with special reference to the Textile Fibres, Rhea or Ranue, Jute, New Zealand Flax. Their uses and abuses. Brighton and Sussex Natural History Society. By Charles F. Dennet. Brighton, 1875. pp. 8. 8vo.

Bullettino della Societa Entomologica Italiana. Firenze, 1874. Anno Sesto, Trimestre, 1, 2, 3, 4. 8vo.

Jardin Imperial de Botanique de St. Petersburg. 1874. Vol III. No. 1. pp. 168. 8vo.

Annual Report of the State Geologist of New Jersey, for the year 1874. Trenton, 1874. pp. 116. 8vo.

Elementary Collection of Minerals and Rocks, with Brief Descriptions. By Rev. E. Seymour. New York, 1874. pp. 37. 8vo.

The Transactions of the Academy of Science. St. Louis, 1875. Vol. III, No. 2. 8vo.

Tidsskrift for Populære Fremstillinger af Naturvidenskaben. Kjobenhavn, 1875. Andet blnds, Forste Hætte. 8vo.

The Entomologist's Monthly Magazine. London, Apr. 1875. 8vo.

Societe Entomologique de Belgique. Serie II, No. 10. pp. 10. 8vo.

The American Journal of the Medical Sciences. Philadelphia, April, 1875. 8vo.

Jahrbucher des Nassanischen Vereins fur Naturkunde. Wiesbaden, 1873 and 1874. xxvii and xxviii. pp. 258. 8vo.

Verhandlungen des naturhistorischen Vereines der preussischen Rheinlande und Westfalens. Bonn. Dritte Folge, Jahrgang 10. Pt. 2. 1873. Vierte Folge, Jahrgang 1, Pt. 1. 1874. 8vo.

Sitzungsberichte der Gesellschaft Natur-forschender Freunde Zu. Berlin, 1874. 8vo.

Deutsche Entomologische Zeitschrift. Jahrg. xix, Heft 1. 1875. 8vo.

Entomological Society of the Province of Ontario, Report of 1874. Toronto, 1875. pp. 62. 8 vo.